La Niña Update, Recent Weather Patterns and the February-April 2012 Outlook For Colorado

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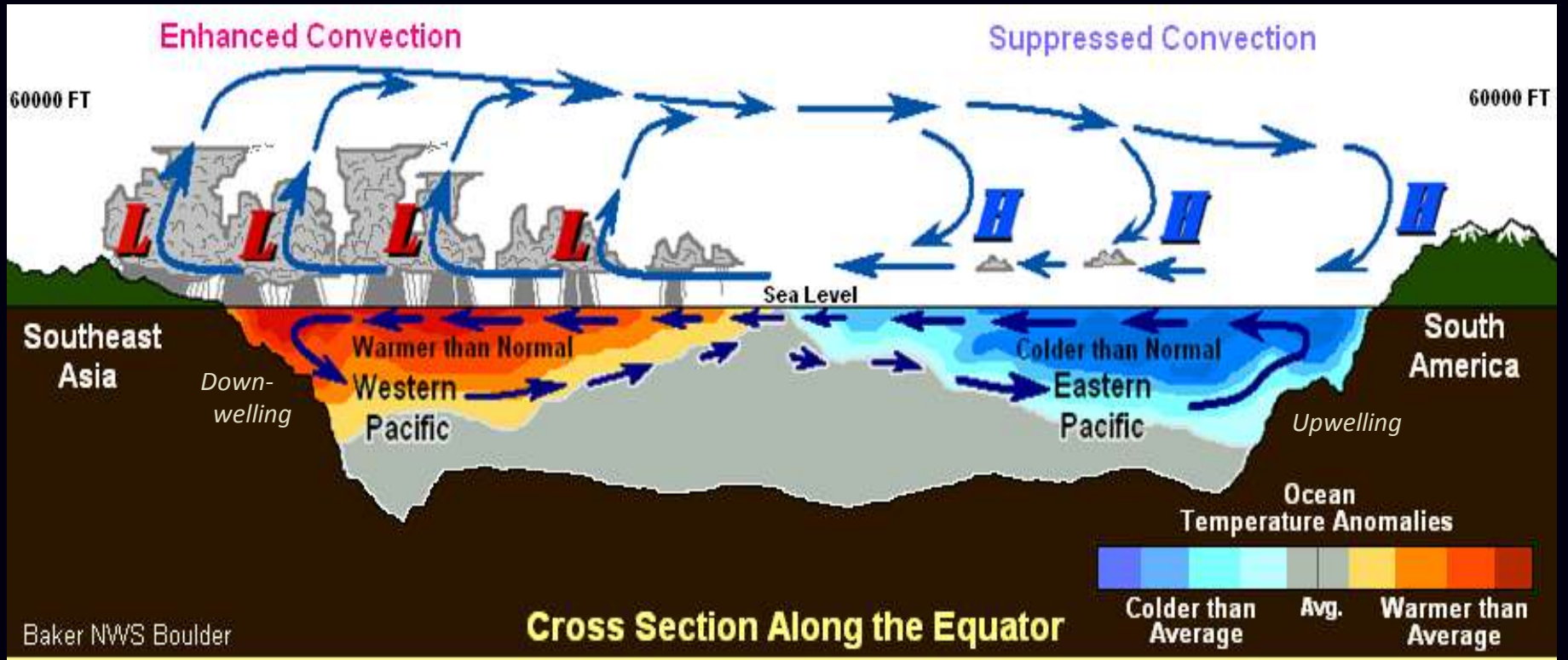
Strong Pacific Jet Stream
La Niña
Continues
Warmer than
Average
Ocean
Colder than
Average
Ocean



Mean Atmospheric and Oceanic Circulations During La Niña

Large-scale oceanic and atmospheric circulations in the tropical Pacific Ocean continue to indicate the presence of a weak to moderate La Niña. These circulations include low-level easterly and upper-level westerly wind anomalies over the equatorial Pacific Ocean and an anomalously strong westerly sub-surface ocean current along the Equator. This enhances cold water upwelling off the coast of South America which then suppresses convection (thunderstorm development) over the eastern Pacific Ocean. Downwelling in the western Pacific warms sea waters and enhances strong convection in this region. These tropical circulations produce horizontal and vertical temperature and pressure gradients that produce and sustain the jet streams that circle the globe.

The Oceanic Niño Index - ONI

Year	DJF	JFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	NDJ
2000	-1.6	-1.4	-1.0	-0.8	-0.6	-0.5	-0.4	-0.4	-0.4	-0.5	-0.6	-0.7
2001	-0.6	-0.5	-0.4	-0.2	-0.1	0.1	0.2	0.2	0.1	0	-0.1	-0.1
2002	-0.1	0.1	0.2	0.4	0.7	0.8	0.9	1.0	1.1	1.3	1.5	1.4
2003	1.2	0.9	0.5	0.1	-0.1	0.1	0.4	0.5	0.6	0.5	0.6	0.4
2004	0.4	0.3	0.2	0.2	0.3	0.5	0.7	0.8	0.9	0.8	0.8	0.8
2005	0.7	0.5	0.4	0.4	0.4	0.4	0.4	0.3	0.2	-0.1	-0.4	-0.7
2006	-0.7	-0.6	-0.4	-0.1	0.1	0.2	0.3	0.5	0.6	0.9	1.1	1.1
2007	0.8	0.4	0.1	-0.1	-0.1	-0.1	-0.1	-0.4	-0.7	-1.0	-1.1	-1.3
2008	-1.4	-1.4	-1.1	-0.8	-0.6	-0.4	-0.1	0	0	0	-0.3	-0.6
2009	-0.8	-0.7	-0.5	-0.1	0.2	0.6	0.7	0.8	0.9	1.2	1.5	1.8
2010	1.7	1.5	1.2	0.8	0.3	-0.2	-0.6	-1.0	-1.3	-1.4	-1.4	-1.4
2011	-1.3	-1.2	-0.9	-0.6	-0.2	0	0	-0.2	-0.4	-0.7	-0.8	

El Niños (warm phase events): ONI of +0.5 and higher (red numbers)

La Niñas (cold phase events): ONI of -0.5 and lower (blue numbers)

ENSO-Neutral (near normal conditions): ONI below +0.5 and above -0.5 (black numbers)

An ONI of -0.8 indicates weak La Niña conditions in the tropical Pacific Ocean during the OCT-NOV-DEC climate season of 2011.

NOAA/CPC Jan 15 2011

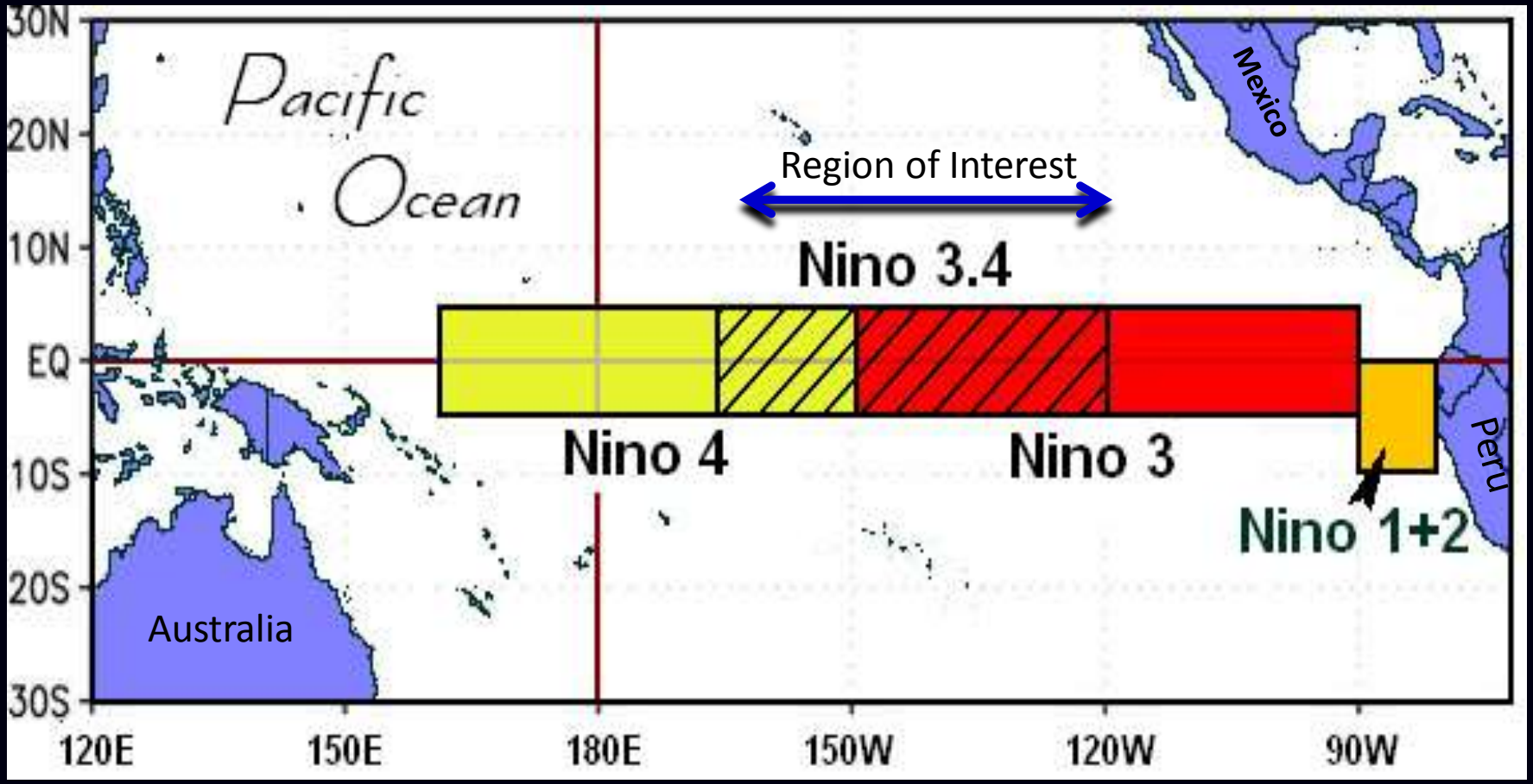
The ONI is based on sea surface temperature (SST) departures from average in the Niño 3.4 region of the eastern tropical Pacific Ocean. It is the principal measure used by NOAA's Climate Prediction Center (CPC) for monitoring, assessing and predicting El Niño/Southern Oscillation (ENSO.)

ONI is defined as the three-month running-mean SST departures in the Niño 3.4 region.

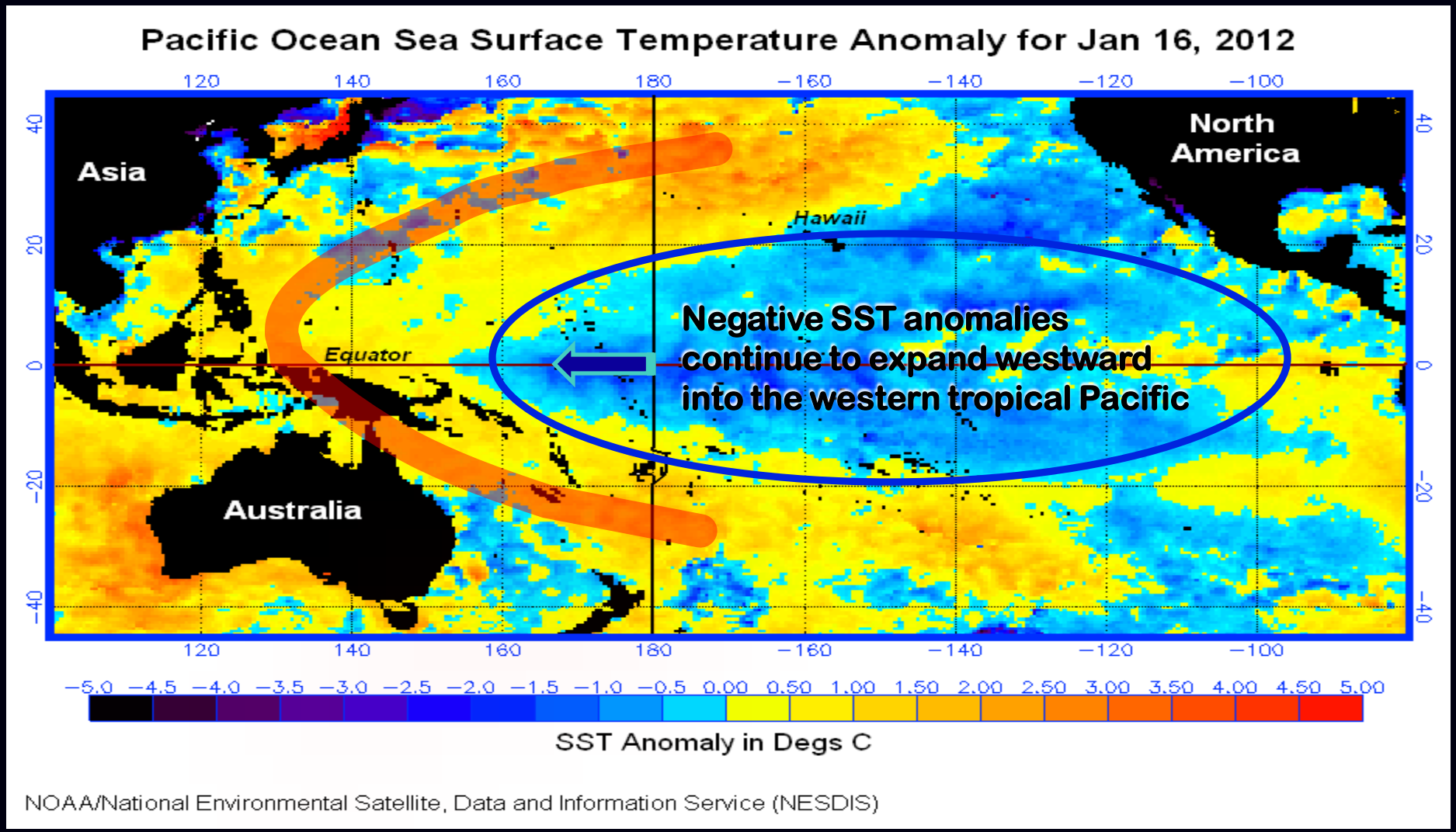
ONI is used to place current ENSO and non-ENSO events into a historical perspective.

CPC's operational definitions of El Niño and La Niña are keyed to the ONI index.

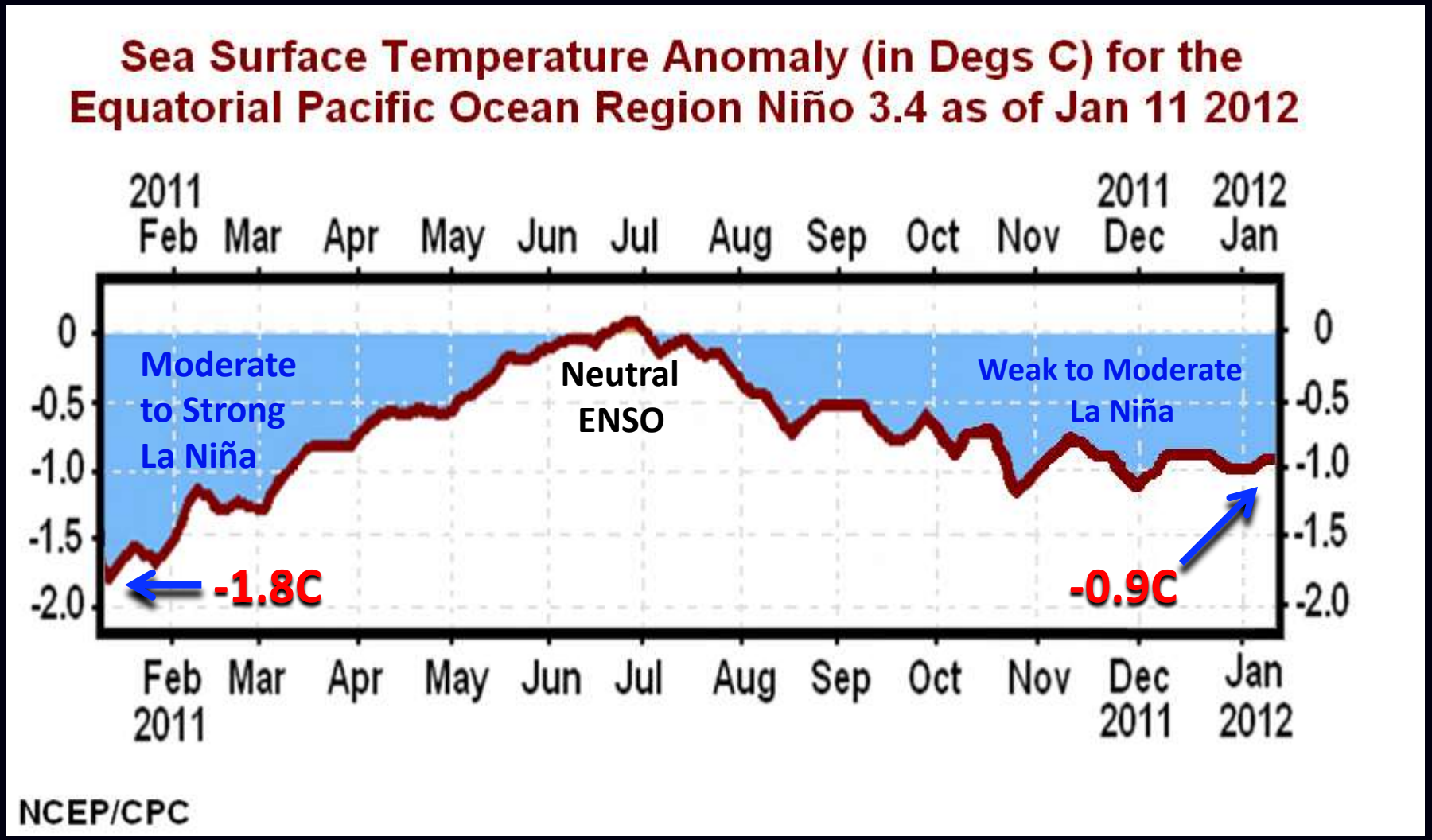
Niño Regions in the Equatorial Pacific Ocean



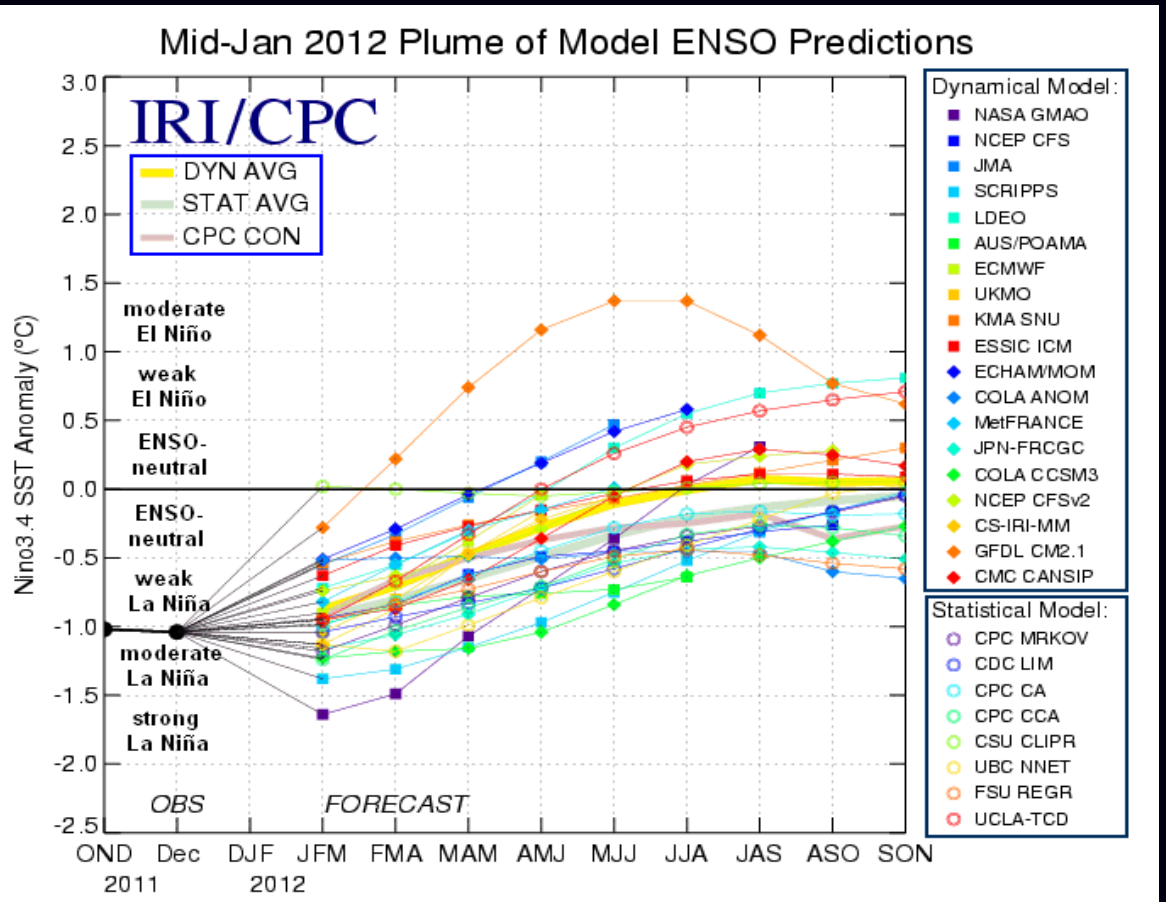
Niño 3.4 – The principal region in the eastern Equatorial Pacific Ocean used by the Climate Prediction Center (CPC) for monitoring, assessing and predicting ENSO (hatched region on the above map) .



Abnormally cold sea surface temperatures (SST) persist in the central and eastern tropical Pacific Ocean, while anomalously warm sea waters are present across the southern Pacific westward to Indonesia and the Philippines in the western Pacific, and northward across the northern Pacific Ocean to the coast of Alaska (in the shape of a horseshoe.)



As of 11 January, 2012 the weekly SST anomaly for Niño 3.4 was -0.9C. One year ago, the SST anomaly for Niño 3.4 was -1.8C. Weekly SST anomalies in Niño 3.4 have remained nearly constant during the past four weeks.



Forecast SST Anomalies (deg C) in the Niño 3.4 Region

	JFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON
Average, dynamic models	- 0.9	- 0.7	- 0.5	- 0.3	- 0.1	- 0.1	- 0	0.1	0
Average, statistical models	- 0.9	- 0.8	- 0.7	- 0.5	- 0.3	- 0.2	- 0.1	- 0.1	- 0.1
Average, for all models	- 0.9	- 0.7	- 0.5	- 0.3	- 0.2	- 0.1	- 0	- 0	0

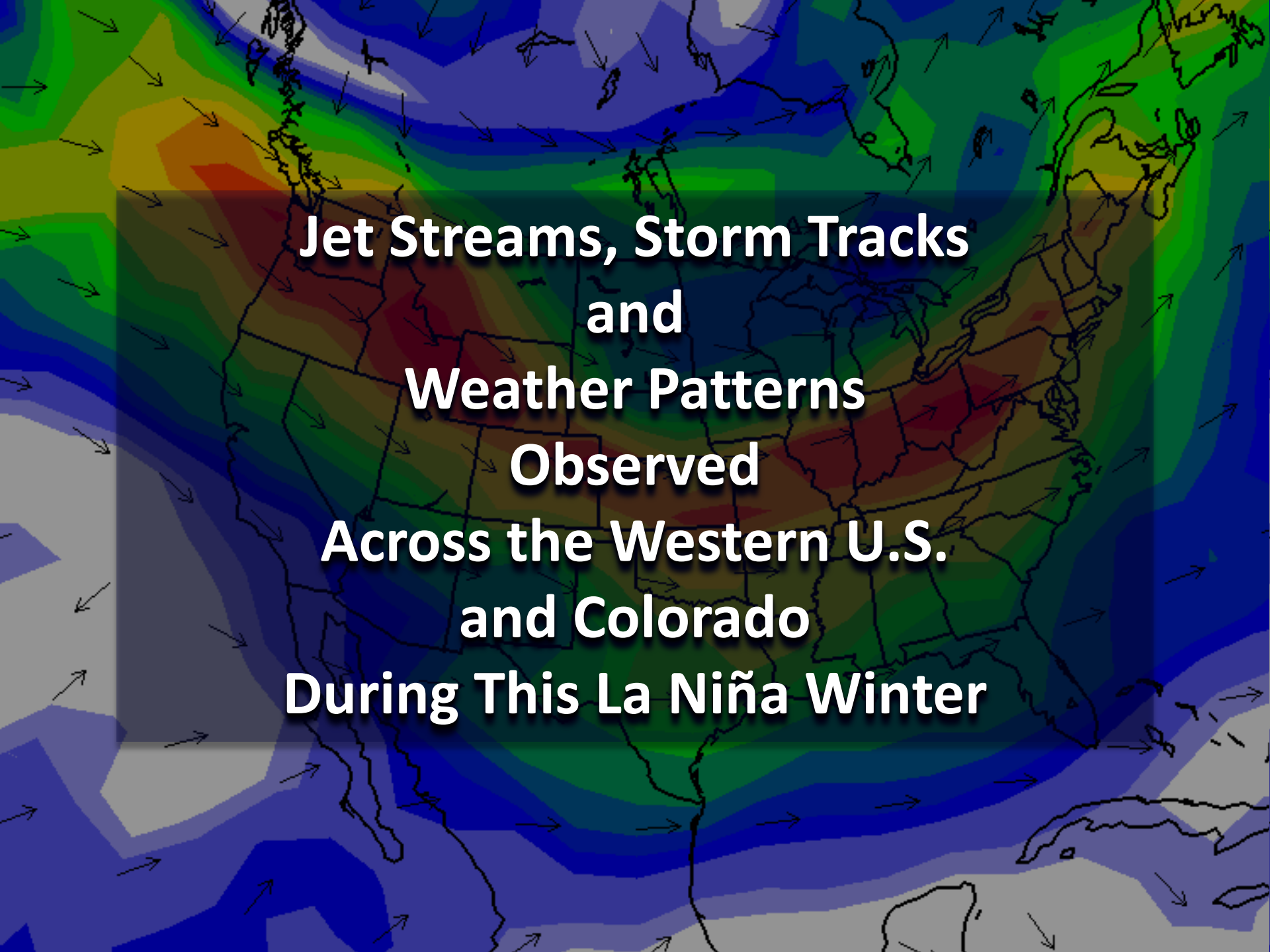
The International Research Institute for Climate and Society / Climate Prediction Center

updated 19 Jan 2012

A majority of the dynamical and statistical ENSO models predict the weak La Niña currently in the Pacific Ocean to continue through the February-March-April climate season and transition to ENSO-neutral conditions by the March-April-May climate season.

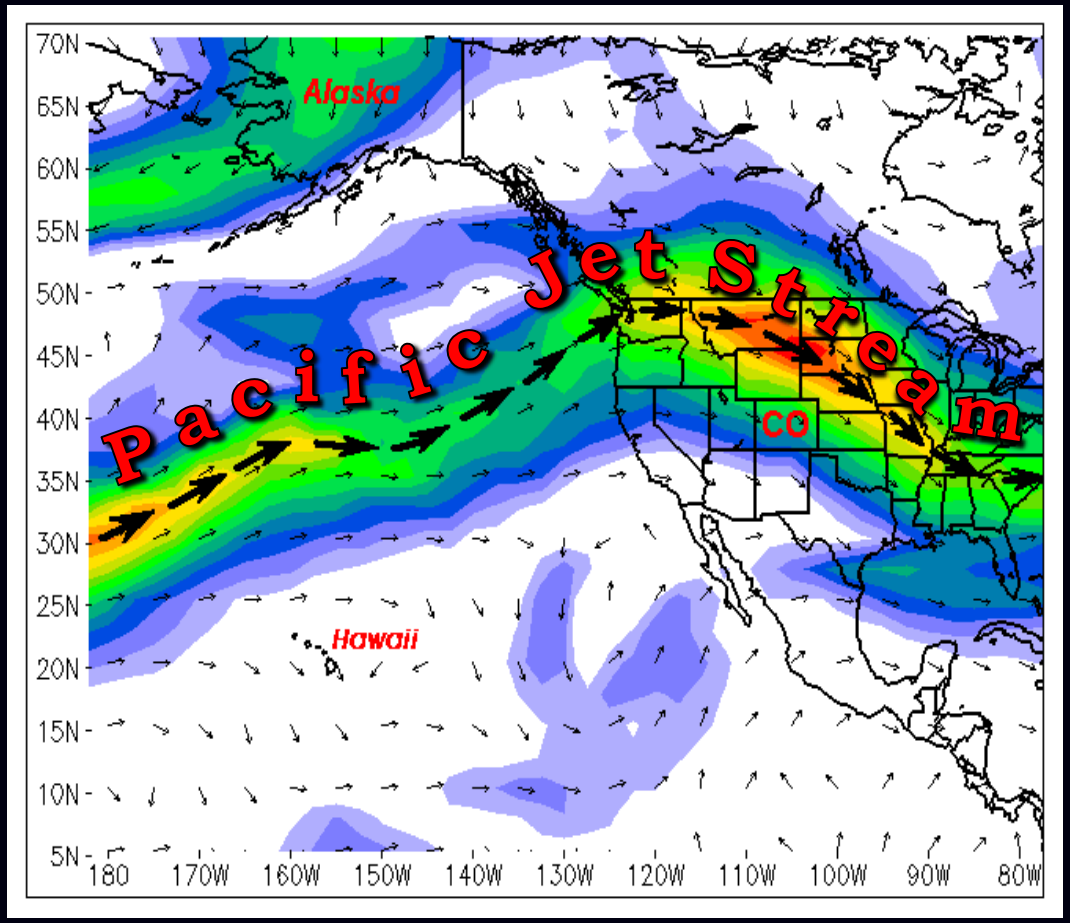
NCEP's Coupled System Forecast Model (CFS) predicts an end to La Niña but not until the April-May-June season.

NASA's Global Modeling and Assimilation Office (GMAO) model goes so far as to predict a strong La Niña until the May-June-July climate season. However, current oceanic and atmospheric conditions do not support this model prognosis.


Jet Streams, Storm Tracks
and
Weather Patterns
Observed
Across the Western U.S.
and Colorado
During This La Niña Winter

The Pacific Jet Stream

- A channel of strong winds within the Westerly Wind Belt (30-60˚ N latitude)
- Produced and sustained by large pressure and temperature gradients between the poles and the Equator
- May be thousands of miles in length, hundreds of miles wide, and thousands of feet deep
- Typically found between 25,000 and 40,000 feet above sea level and sometimes below 25,000 feet AGL during the winter season
- Wind speeds may exceed 180 mph
- Its position can vary significantly from week-to-week and even from day-to-day
- Much of the variability in precipitation, temperature, wind, and cloud cover we see during the winter and spring can be attributed to the jet stream.



1-Day 300mb Mean Wind Vectors

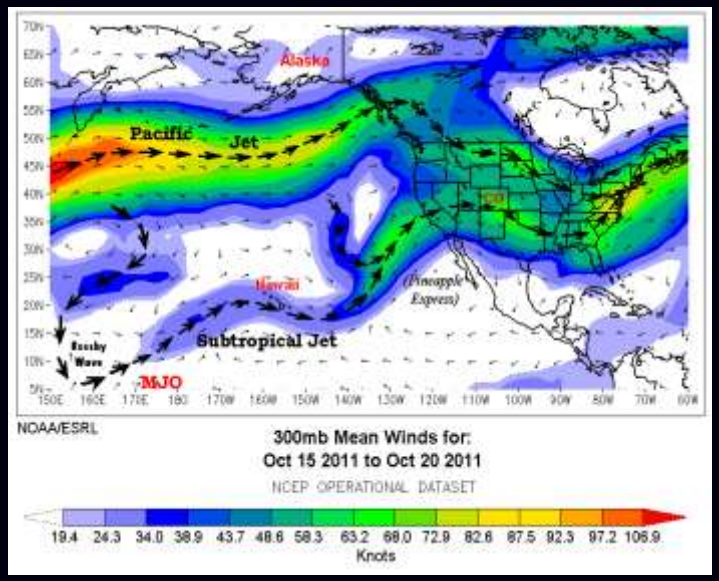
During La Niña-Cold Phase ENSOs

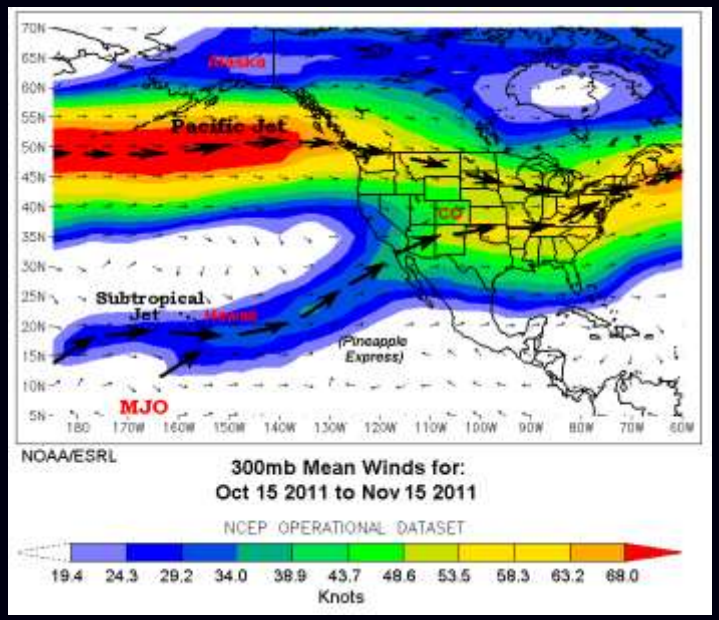
During the winter season of La Niñas, particularly moderate to strong events, the Pacific jet stream is often seen round the top of large, nearly stationary, high pressure ridges along the west coast of the U.S. The jet normally would then curve southeast-ward transporting waves of dense clouds, moderate to heavy precipitation, and strong winds to the central Rocky Mountain region.

During El Niño-Warm Phase ENSOs

During the winter season of El Niños, particularly moderate to strong events, the Pacific jet will often divert southward around a broad, nearly stationary, upper level low pressure trough over the Great Basin. After coming onshore in either central or southern California, it is common to see this jet stream meandering eastward over the desert southwest and southern Rocky Mountain regions, transporting waves of moderate to heavy precipitation and strong winds to areas along the way.

The Mean Jet Stream Pattern over the Western U.S. Last October



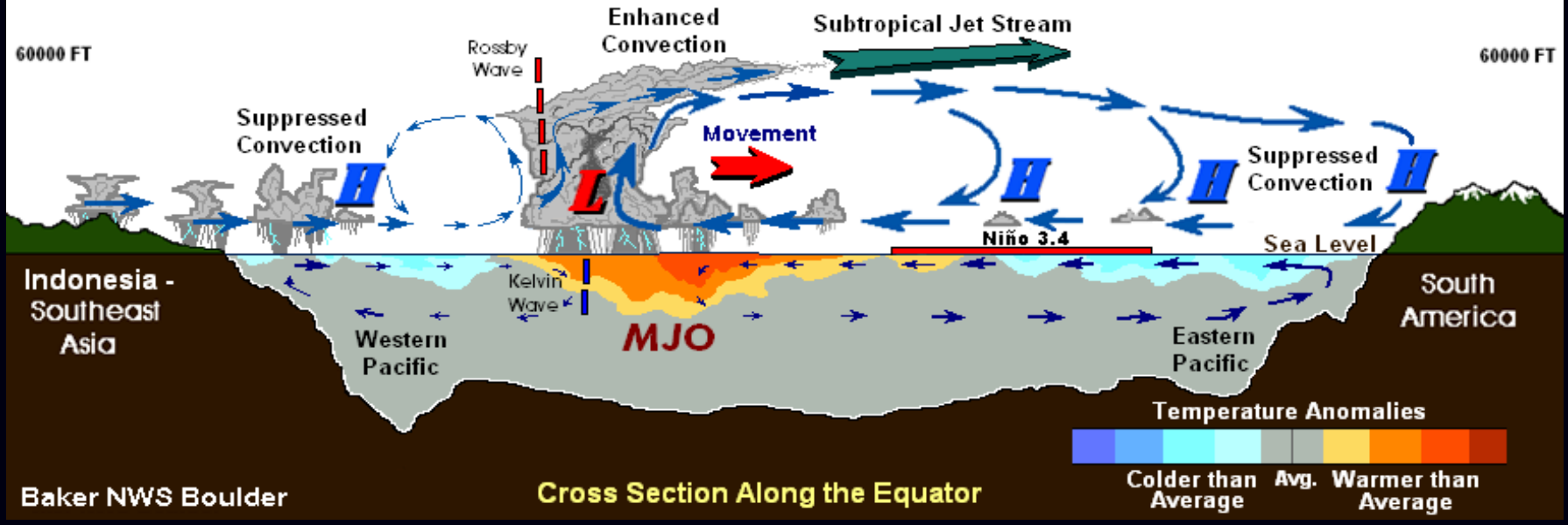


Last October an abnormally strong high pressure ridge formed along the west coast of the U.S. which diverted a powerful Pacific jet stream northward over western Canada.

This poleward shift in the Pacific jet stream coincided with the arrival of a subtropical jet stream over the southwest U.S. This weaker jet stream, sometimes referred to as the "pineapple express", formed over central tropical Pacific Ocean in the vicinity a strong Madden Julian Oscillation (MJO) that was slowly moving eastward along the Equator. These subtropical jet streams can transport a continuous channel of moisture laden air released from deep tropical convection (thunderstorms) as far north as the United States. This past October such a flow of moisture rich air resulted in heavy to record level precipitation across portions of the southwest U.S., over a several day period. Strong southwest winds associated with this jet stream also created blizzard conditions in many of the high mountain ranges of southwest Colorado and northwest New Mexico.

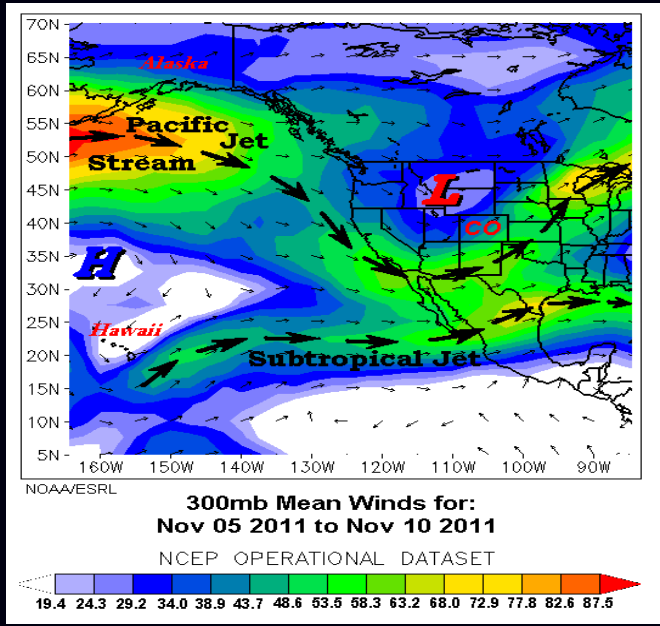
Even though weak La Niña conditions existed in the Pacific , the unusually wet, snowy and windy conditions produced by this jet stream resemble conditions normally observed during El Niño events, particularly those of moderate to strong intensity.

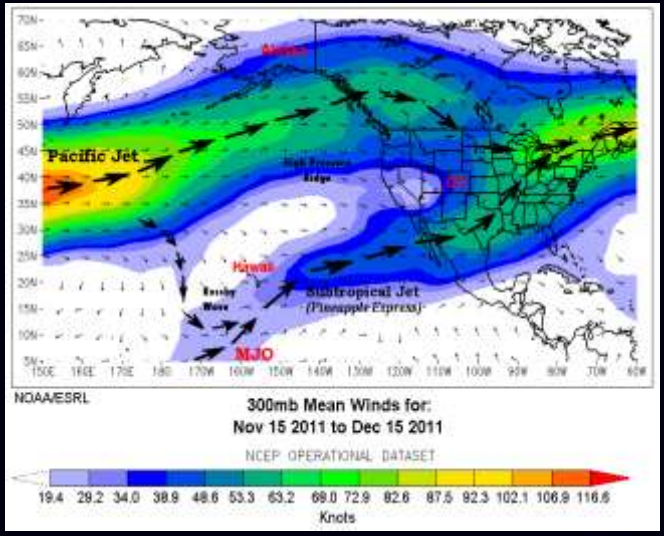
Madden-Julian Oscillation (MJO) in the Tropical Pacific Ocean



The Madden-Julian Oscillation (MJO), also known as the 30-60 Day Tropical Wave, is a large-scale coupling of tropical oceanic (Kelvin Wave) and atmospheric (Rossby Wave) circulations that circle the globe on an intraseasonal time scale ordinarily within a span of 30 to 60 days. MJOs are characterized as a large eastward propagating region of enhanced and suppressed tropical convective rainfall, observed mainly over the Indian and Pacific Oceans. MJOs that manage to reach the eastern tropical Pacific Ocean (specifically the Niño 3.4 region of the Pacific) can significantly impact temperature, precipitation, and circulation patterns from Hawaii to the continental United States. These conditions are similar to those observed during El Niño events, yet appear for a much shorter period of time. MJOs form most often during weak La Niñas and ENSO-neutral conditions, and are weakest or absent during El Niño events.

The Mean Jet Stream Pattern over the Western U.S.
Last November and Early December



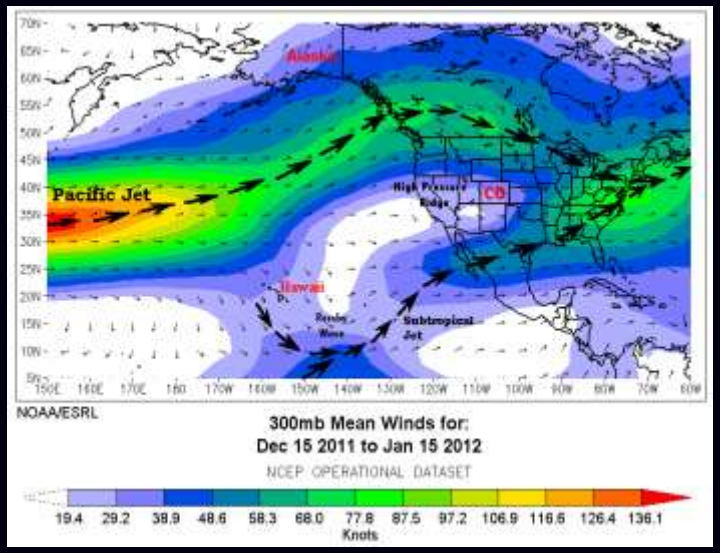


In early November 2011, the high pressure ridge along the west coast migrated farther out over the eastern Pacific Ocean allowing the Pacific jet stream over Canada to plunge southward over the southwest U.S. and northern Mexico, where it merged with the subtropical jet stream in the area. This convergence of jet streams resulted in several days of heavy precipitation, strong winds and severe storms downstream across the southern and eastern portions of the U.S.

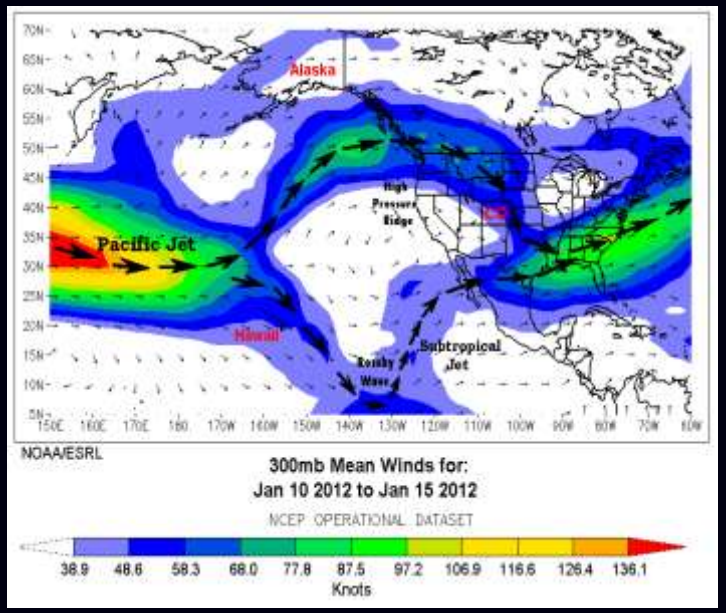
The southward shift in the Pacific jet stream also produced very dry conditions across much of the western U.S. Before this shift in the Pacific jet stream, a series of Canadian cold fronts pushed along by strong northwest flow aloft, raced south along the east face of the Rocky Mountains. These quick hitting frontal systems, sometimes referred to as “Alberta clippers,” deposit several inches of snow along the Colorado Front Range. Many locations including Denver ended the month of November with above average snowfall.

During the last half of November and the first half of December, the Pacific jet stream returned to western Canada with the strong high pressure ridge returning to its former position off the west coast of North America.

The Mean Jet Stream Pattern over the Western U.S.
Late December and Early January

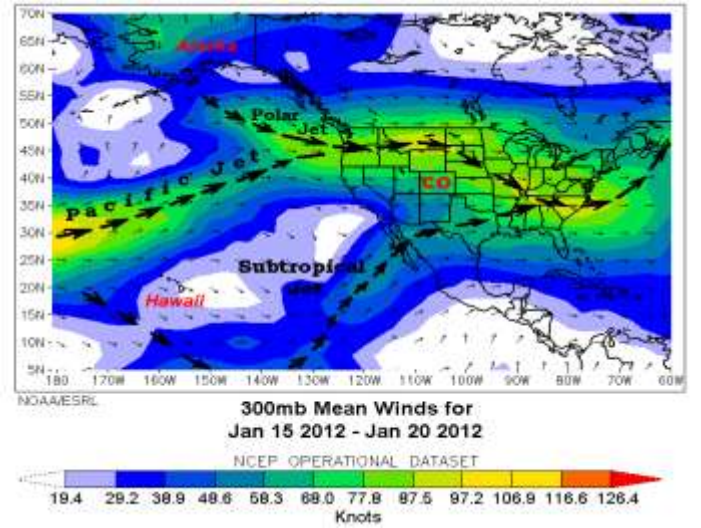


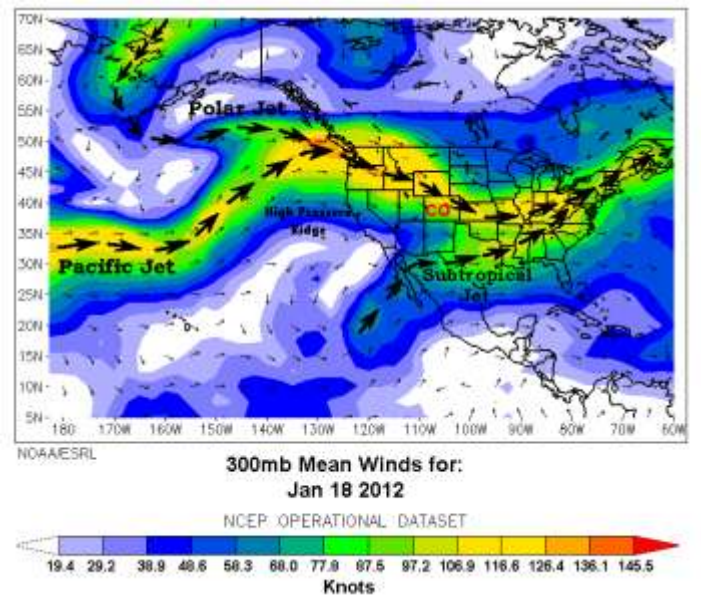
During the last half of December of 2011 and the first week of January 2012, the mean position of the Pacific jet stream remained up over western Canada, with an abnormally strong high pressure ridge anchored along the west coast of the U.S. Most of the storms carried along by this powerful jet stream passed to the north of the Pacific Northwest. This resulted in unseasonably warm and dry conditions for the region, as well as for most of the western U.S.



By the second week in January, the large scale circulation pattern over the western U.S. and Canada was showing signs of a significant change. The mean position of the Pacific jet stream was starting to shift southward with the strong west coast high pressure ridge weakening and sliding southward. This shift in the jet stream placed the storm track squarely over the Pacific Northwest. The result was days of heavy rainfall, gale force winds, and blinding mountain snowfall.

The Mean Jet Stream Pattern over the Western U.S. During the Middle of January of 2012



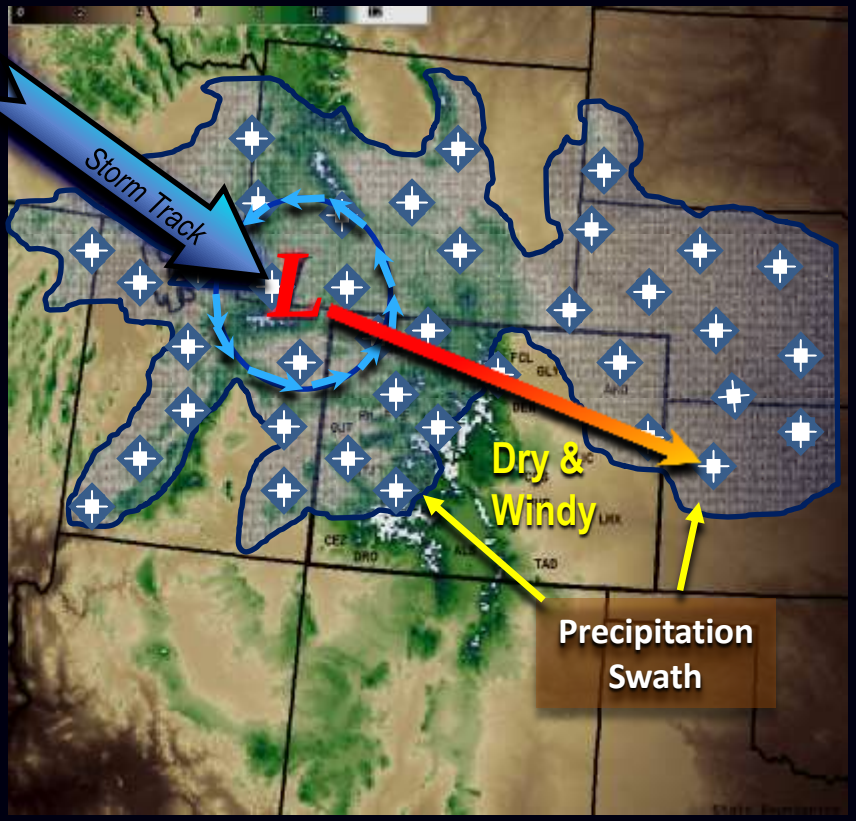


By the middle of January, the Pacific Jet stream and storm track remained over the Pacific Northwest. The exceptionally wet, snowy and windy weather continued to pound the region. However, the Pacific jet stream had now merged with its colder counterpart, the Polar jet stream. This sent temperatures falling and the snow level down to sea level along the coast of Washington. Winds became stronger, with many mountain tops experiencing hurricane force wind speeds. Farther east, the storm track has shifted southward over southern Idaho and central Wyoming.

During the next few days, the exceptionally strong northwesterly flow aloft grew even stronger as the two merged jet streams continued their southward migration over southern Wyoming and northern Colorado. This shift in the jet stream/storm track resulted in a significant increase in snowfall and winds across northwest and west central Colorado. Hurricane force winds caused blizzard conditions on many of the high mountain passes. Areas east of the Colorado Front may have escaped the precipitation, but not the strong winds. Parts of the Front Range recorded frequent wind gusts in excess of 100 mph!

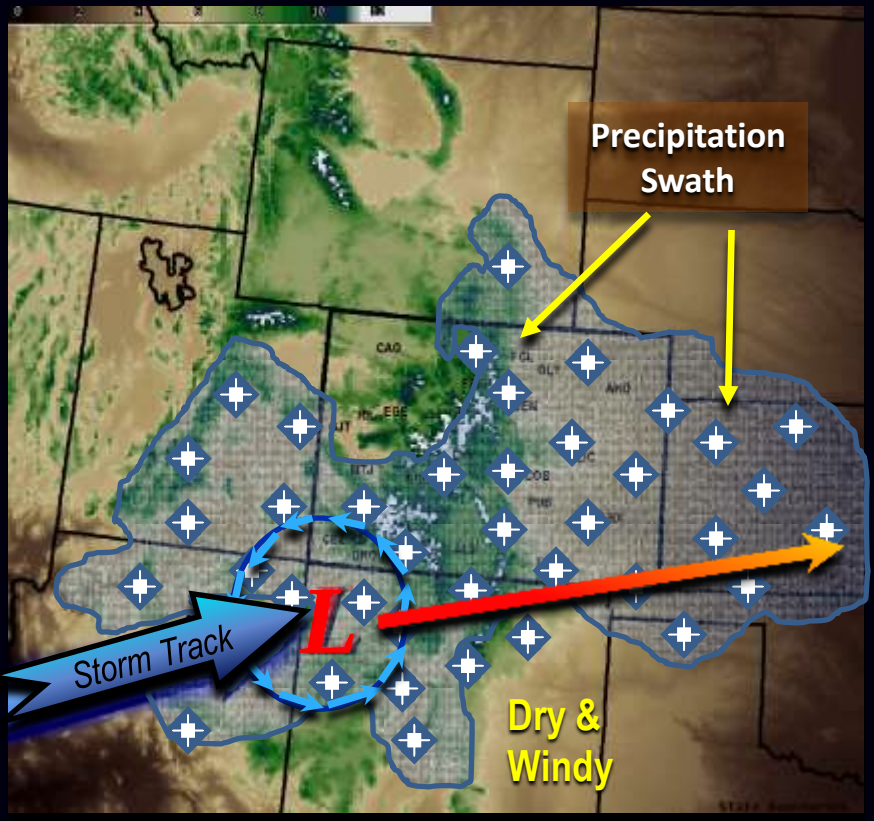
Baker - National Weather Service Boulder, Colorado

Winter Storms from the Northwest



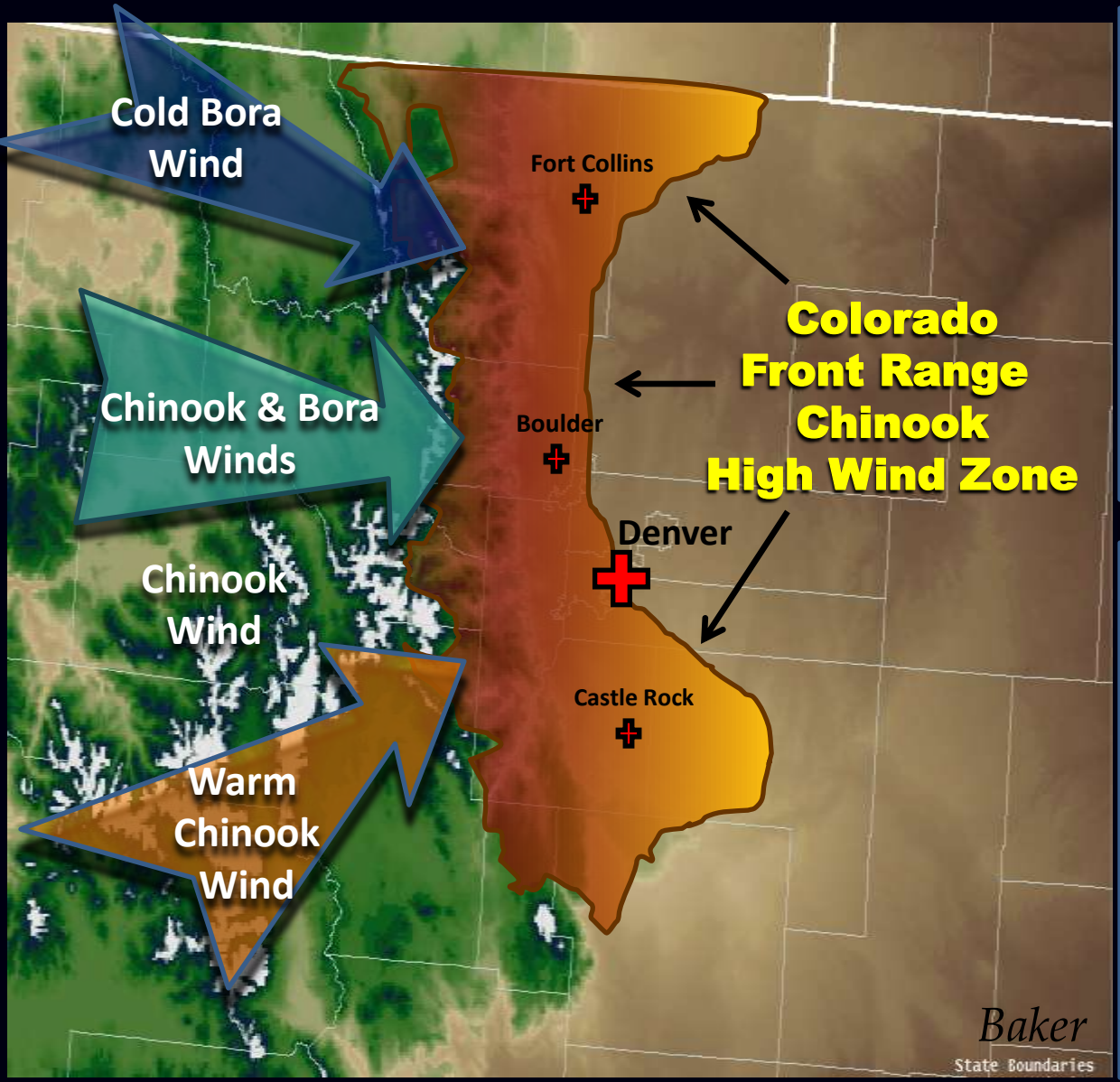
Storms arriving in Colorado from the Pacific northwest will normally deposit much of their precipitation/snowfall on west and northwest facing mountain slopes in northwest and west central Colorado. These usually fast moving Pacific storm systems are often accompanied by strong winds capable of producing blizzard-like conditions on the high mountain ridges and passes.

Winter Storms from the Southwest



Storms arriving in Colorado from the desert southwest will normally deposit much of their precipitation/ snowfall on south and southwest facing mountain slopes in southwest and south central Colorado. These slower moving storms can occasionally produce strong winds capable of blizzard-like conditions on the mountain ridges as well as on plains of eastern Colorado. Storms may also deposit heavy snowfall along the east face of the Front Range mountains.

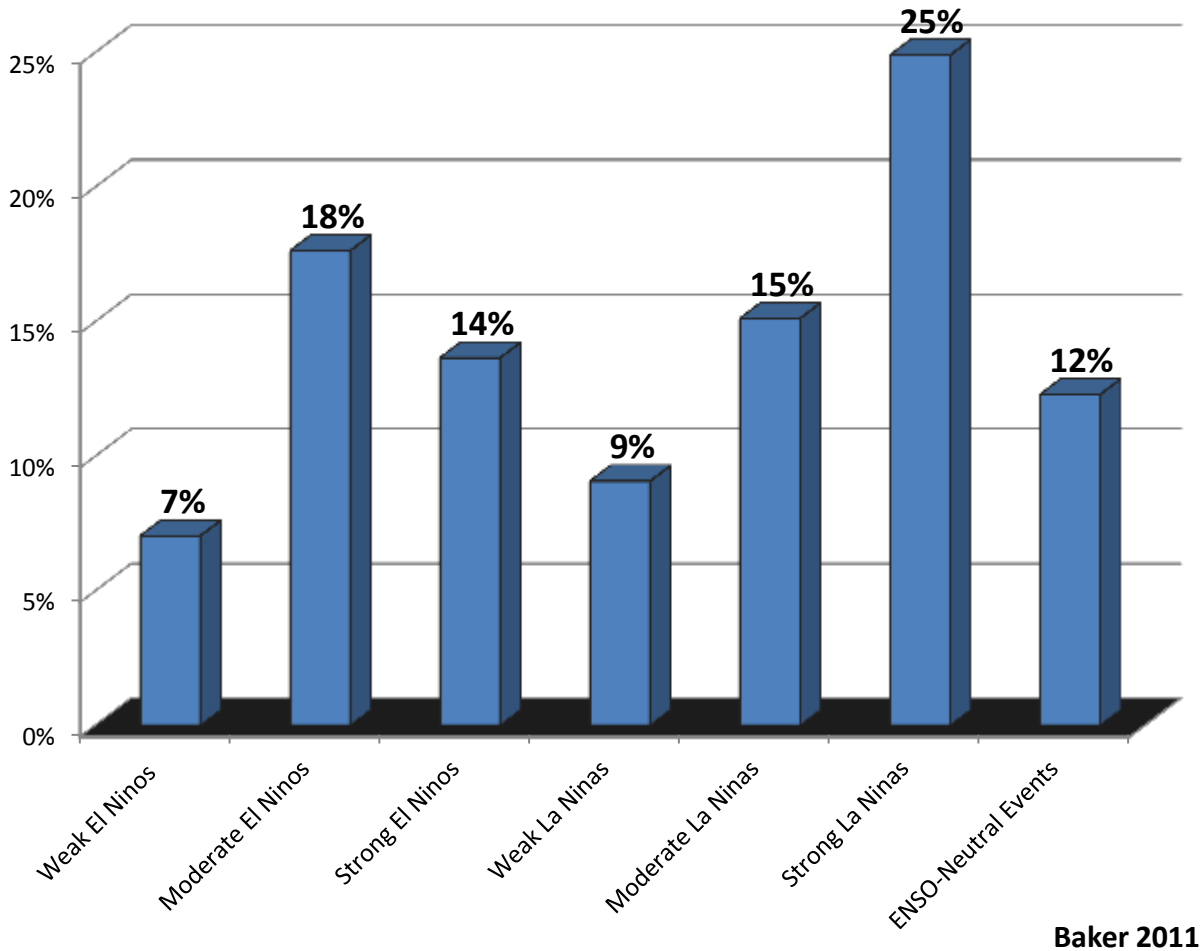
Gusty downslope winds known by the names of **Chinook** and **Bora** commonly occur along the Colorado Front Range during the fall, winter and spring.



Chinook (a native American word meaning snow eater) is a warm and often very dry wind that blows down the east face of the Front Range and onto the nearby plains but rarely extend more than 20 miles from the foothills . These gusty and erratic winds can reach speeds well in excess of 100 mph with a strong cross mountain pressure gradient.

The Bora is a cold and often dry wind that rushes down the east face of the Front Range and Cheyenne Ridge normally following the passage of a fast moving Pacific cold front. The Bora wind can extend well across the northeast plains of Colorado where it can reach speeds in excess of 60 mph. A strong jet stream is often nearby when this cold and often strong wind occurs.

Percentage of High Wind Days In the Boulder Area During ENSO and ENSO-Neutral Events, 1969-2010



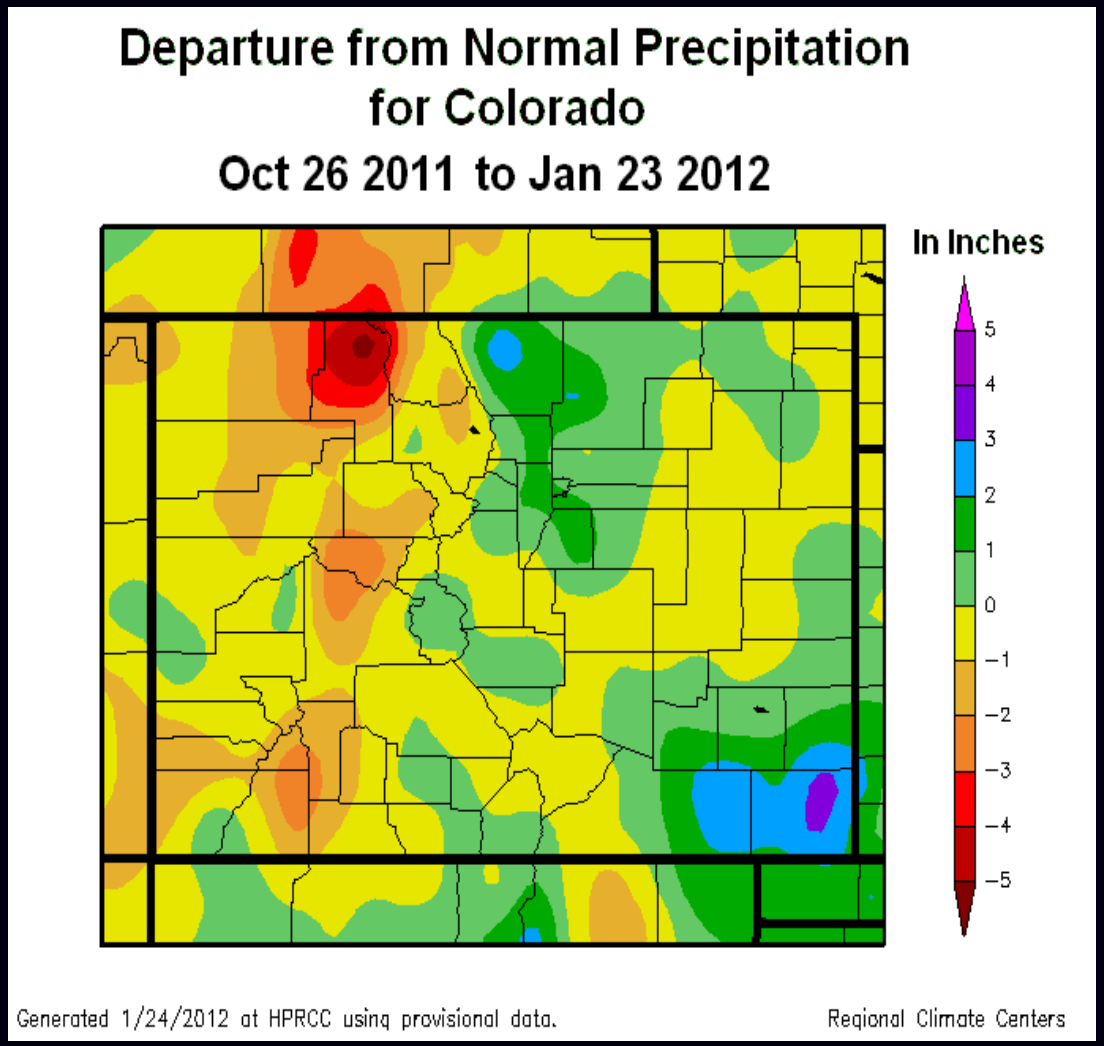
Baker 2011

High Wind Days – A day when the speed of a sustained wind or wind gust equals or exceeds 70 mph.

In and around Boulder, Colorado, high winds (both the Chinook and Bora) historically (1969-2010) occurred most often during strong La Niñas (25 percent of the time) and during moderate El Niño events (18 percent of the time), followed by moderate La Niña events (15 percent of the time).

High winds in the Boulder area were observed least often during conditions associated with weak El Niño and weak La Niña events (7 percent and 9 percent, respectively).

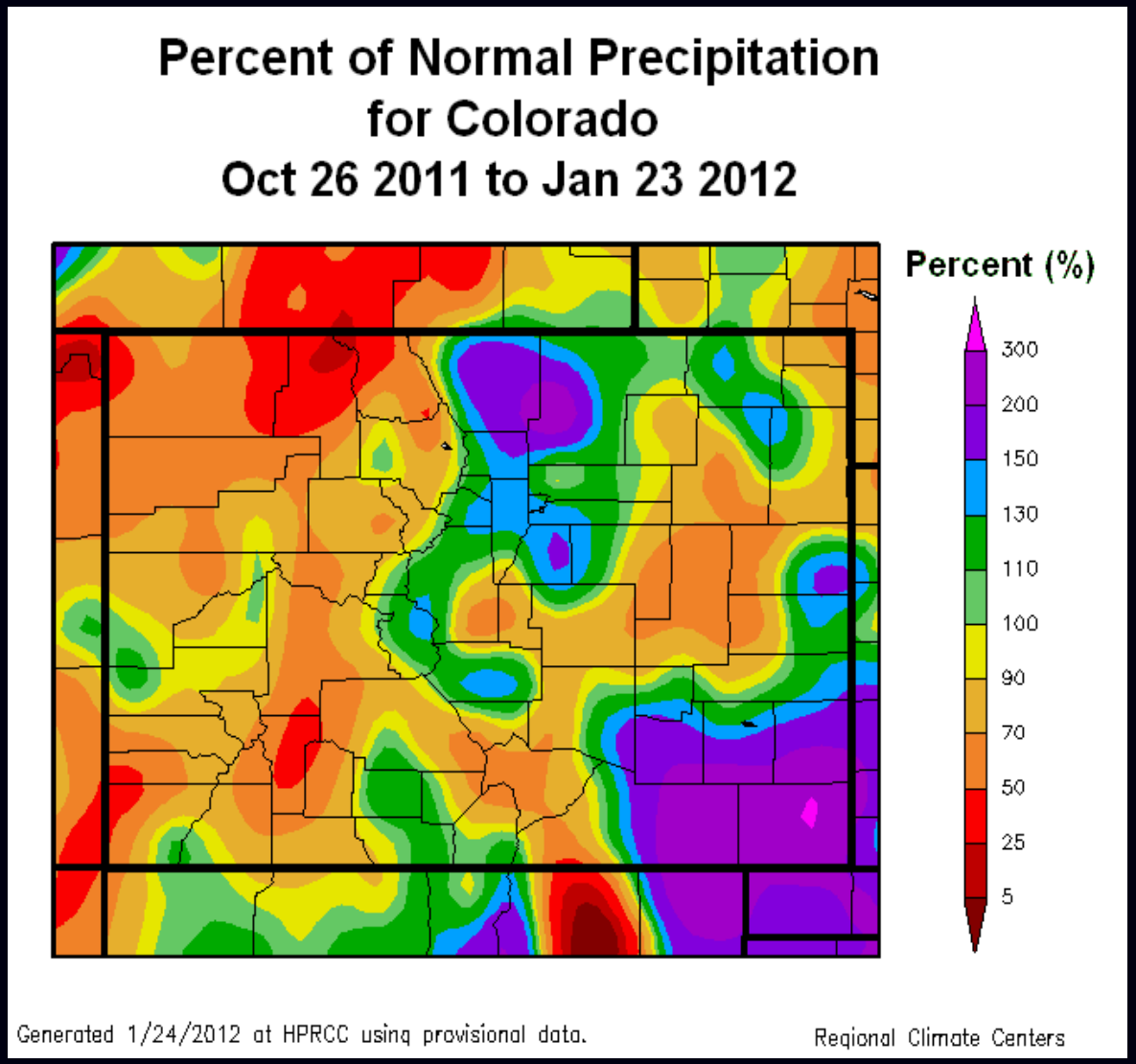
Temperature, Precipitation, and Drought Conditions Across Colorado During the 90-Day Period October 26, 2011 to January 23, 2012



During the 90-day period ending January 23, 2012 , the Upper Yampa River Basin in northwest Colorado recorded the greatest precipitation deficit in the state. Precipitation totals for the rest of western Colorado generally ranged from 0.5 to 2.5 inches below normal.

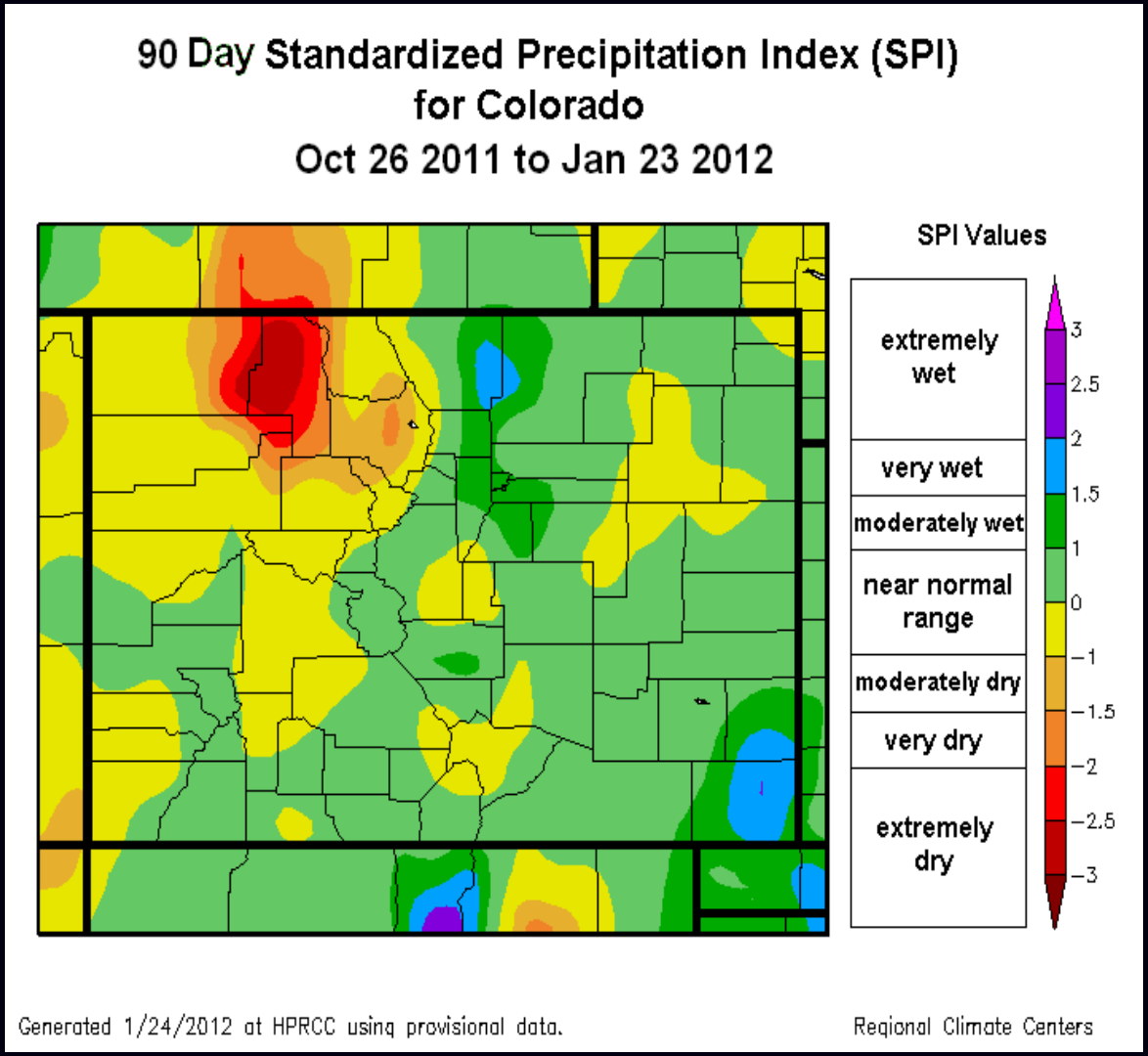
In contrast, southeast Colorado had the greatest precipitation surplus with nearby 3 inches of precipitation above normal in Baca county.

Positive precipitation anomalies were also reported along the east face of the Front Range in northeast Colorado, the Upper Arkansas River Basin in central Colorado and portions the Upper Rio Grande Basin in south central Colorado.



During this same 90-day period, above normal precipitation was recorded along the Front Range and South Platte River in northeast Colorado, over the Mosquito and Rampart Ranges in central Colorado, and on the southeast plains were totals were as much as 300 percent of normal.

In western Colorado, precipitation totals generally ranged from 30 to 90 percent of normal, with pockets of precipitation less than 20 percent of normal in southwest Colorado, on the northern slope of the San Juan Mountains, and up along the Wyoming border north of Steamboat Springs.

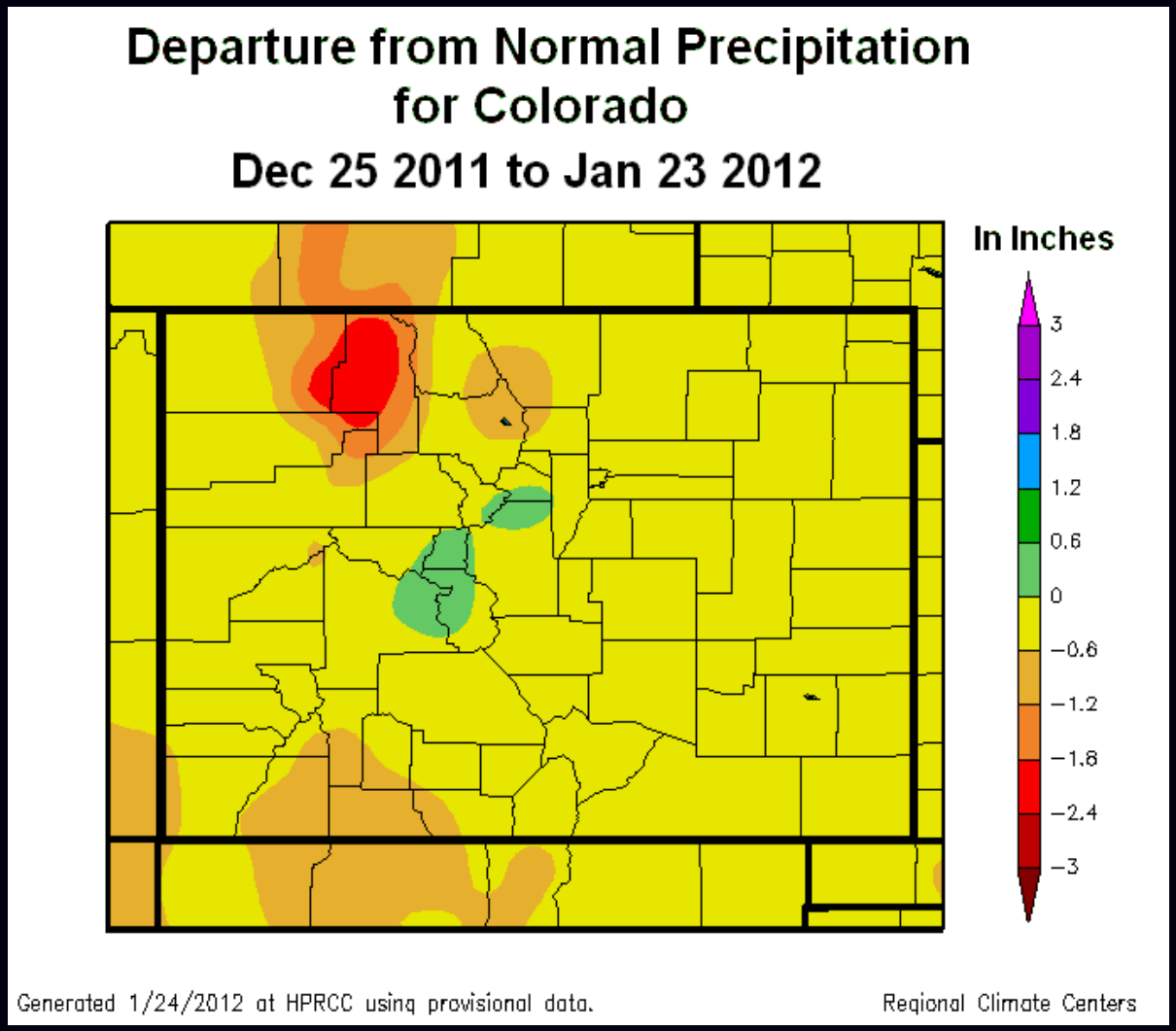


The Standardized Precipitation Index (SPI) for the 90-day period ending January 23, 2012 revealed extremely dry conditions in the Upper Yampa River Basin in northwest Colorado, and near normal to very dry conditions across the rest of western Colorado.

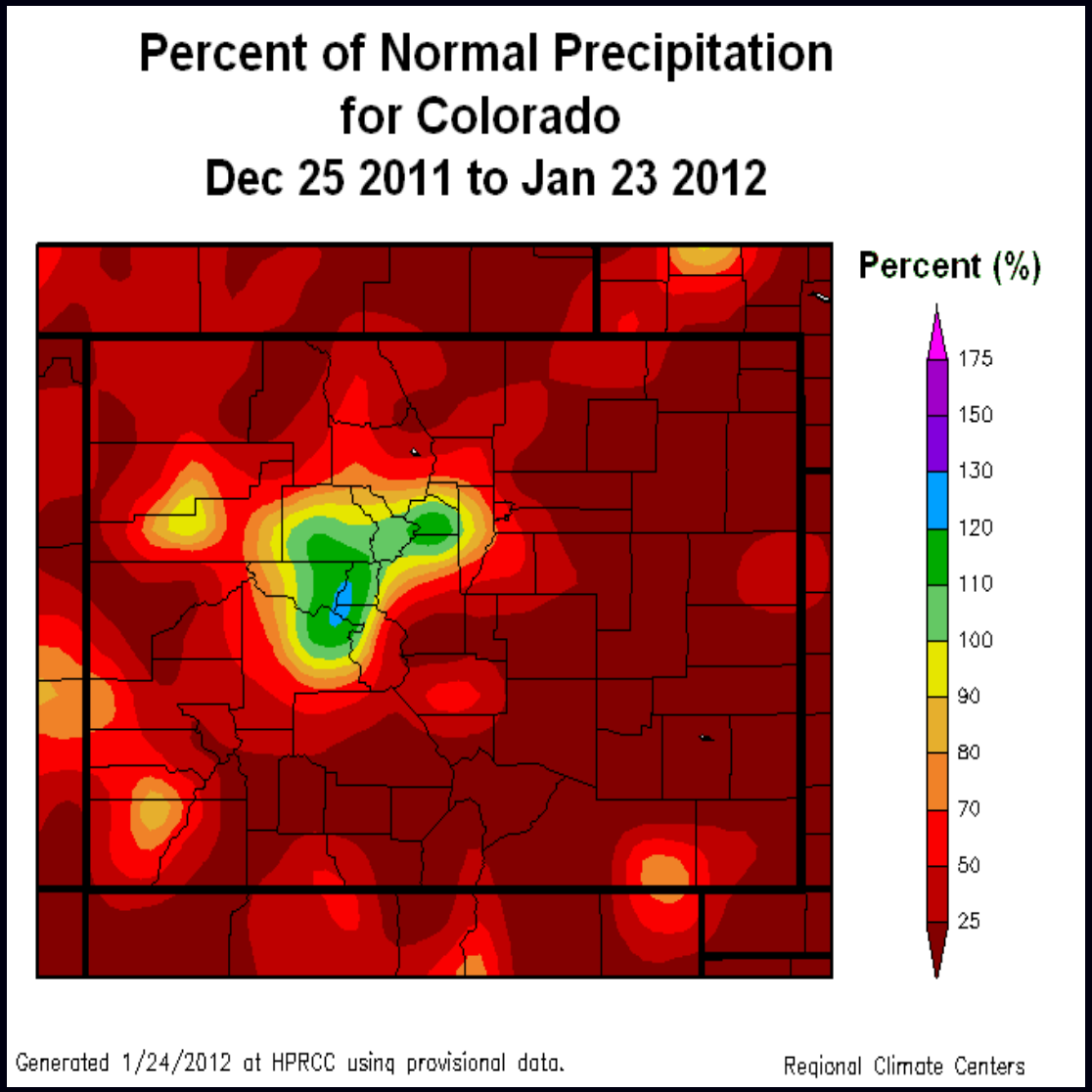
Elsewhere, conditions varied from near normal to very wet conditions along the northern Front Range and southeast corner of the state.

The SPI was developed to monitor potential short term agricultural and long-term hydrological drought conditions. The SPI is a probability index that considers only precipitation.

Temperature, Precipitation, and Drought Conditions Across Colorado During the 30-Day Period December 25, 2011 to January 23, 2012



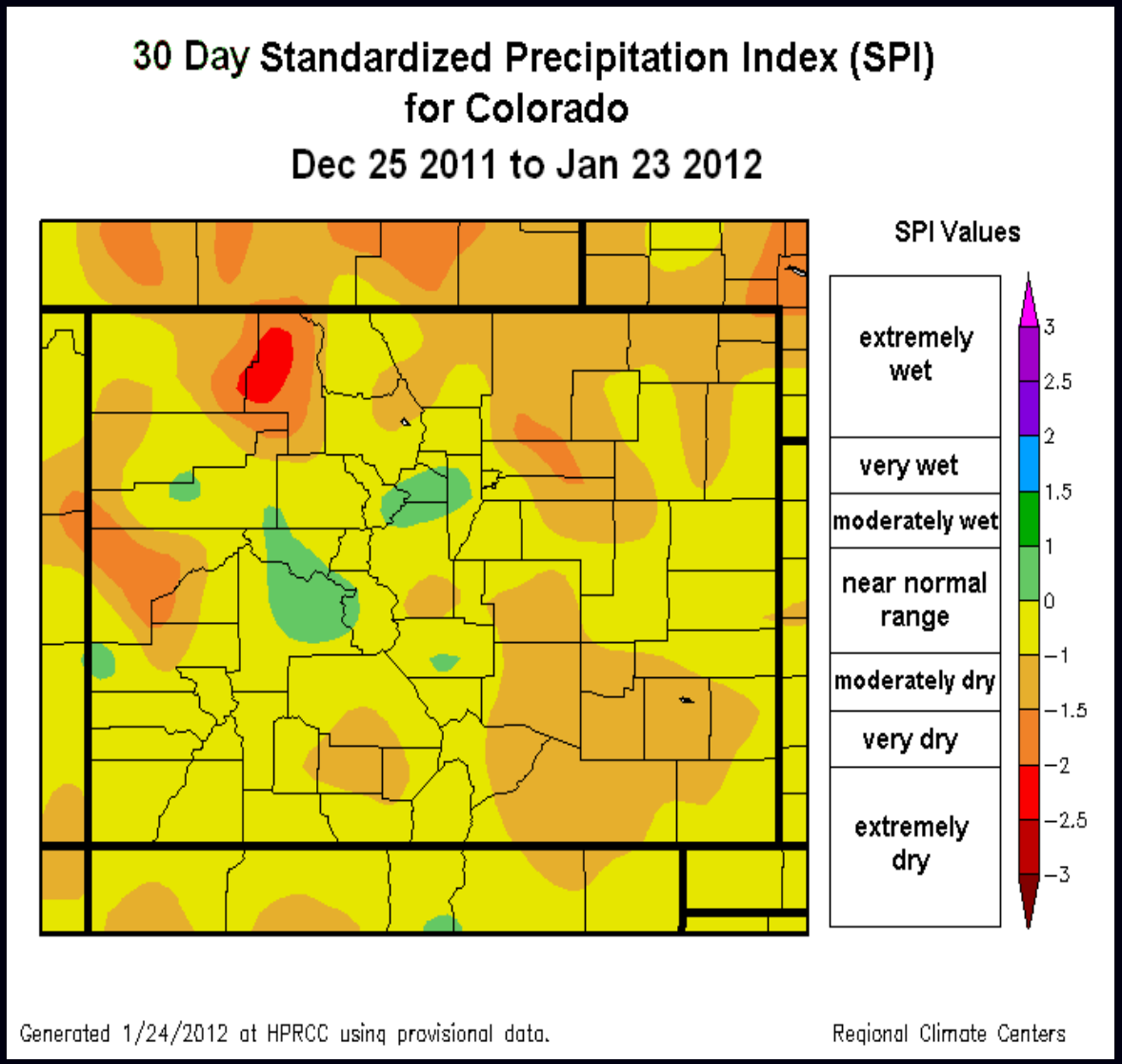
During the 30-day period ending December 20, 2011, precipitation departures across Colorado varied from near 2.4 inches below normal in northwest Colorado to approximately 0.5 inch above normal for the upper reaches of the Arkansas River Valley around Leadville.



There was a significant absence in precipitation for nearly all of Colorado during the 30-day period ending Jan 23, 2012.

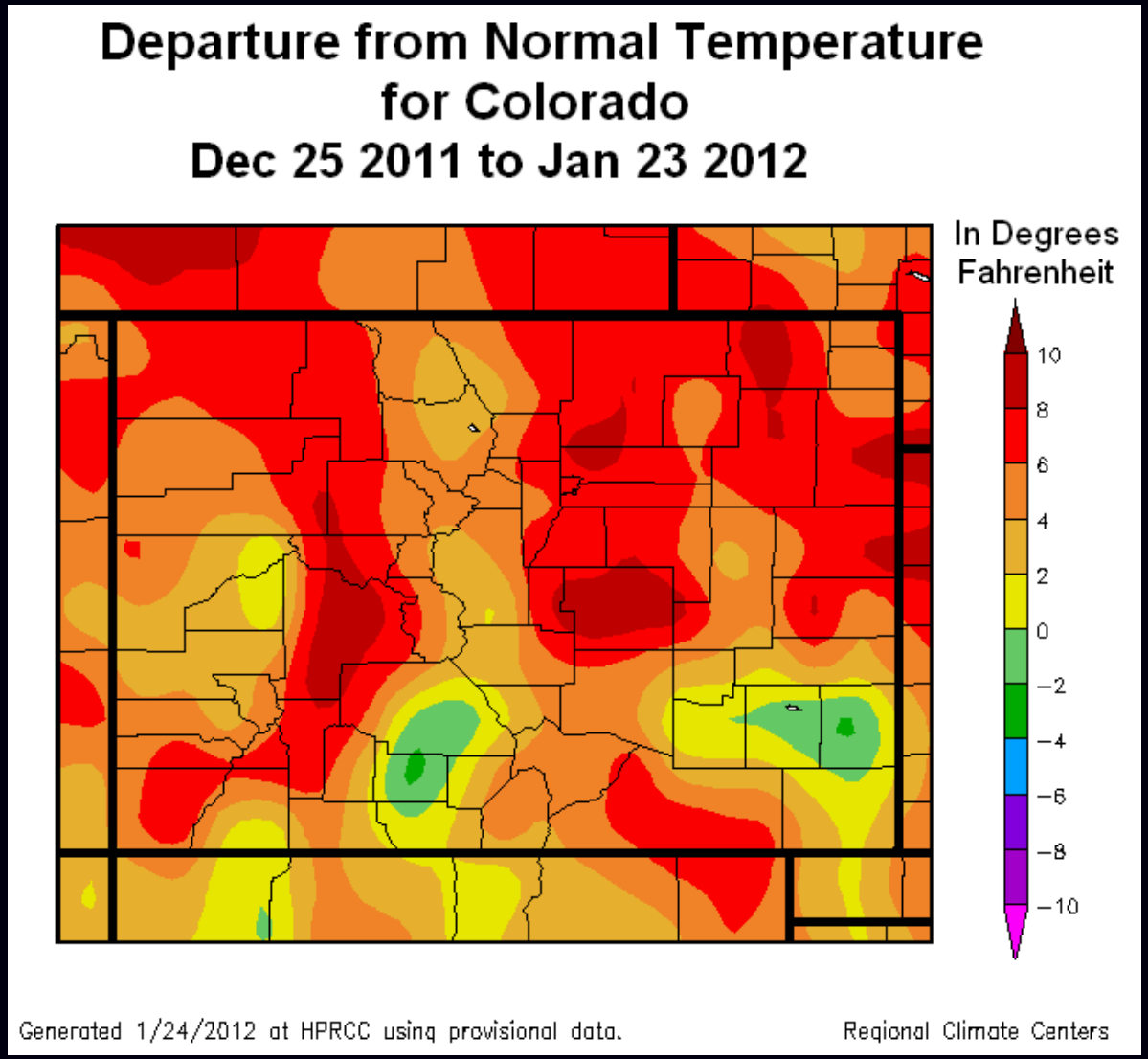
One exception to this was in central Colorado around the cities of Aspen, Vail, Leadville, Breckenridge and Dillon in central Colorado.

These well known mountain communities and the rugged terrain that surrounds them recorded precipitation amounts 110 to 130 percent of normal, thanks in large part to a shift in the prevailing winds that brought in waves of badly needed moisture from the Pacific Northwest.



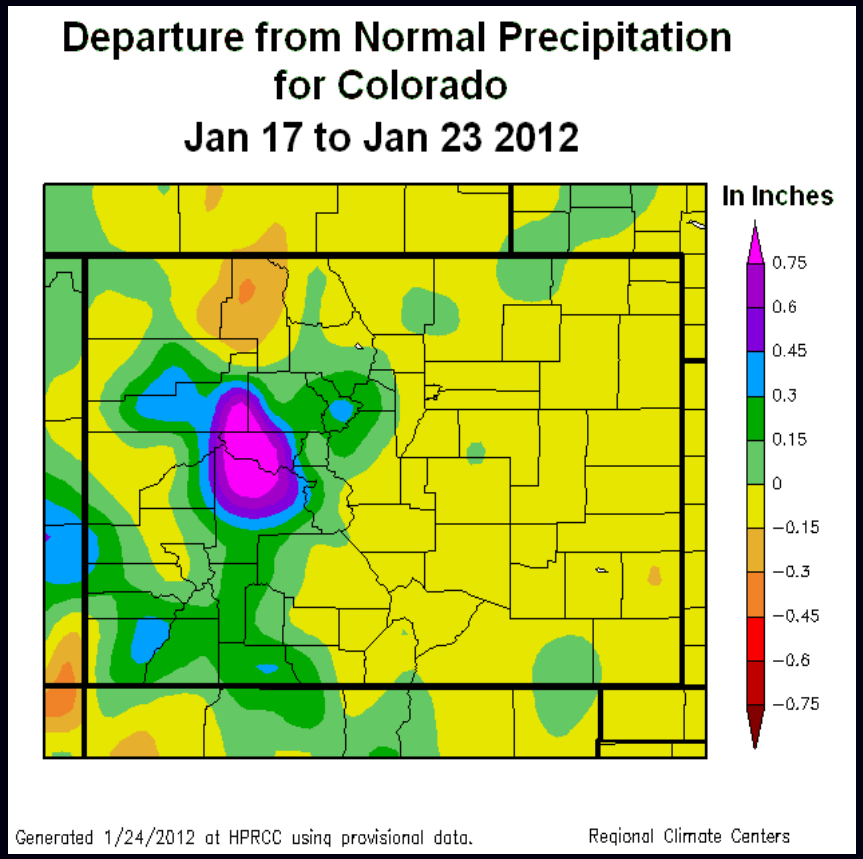
The Standardized Precipitation Index (SPI) for the 30-day period ending January 23, 2012 continues to draw attention to the extremely dry conditions plaguing the Upper Yampa River Basin in northwest Colorado. Very dry conditions were also indicated along lower sections of the Gunnison and Colorado River valleys in west central Colorado.

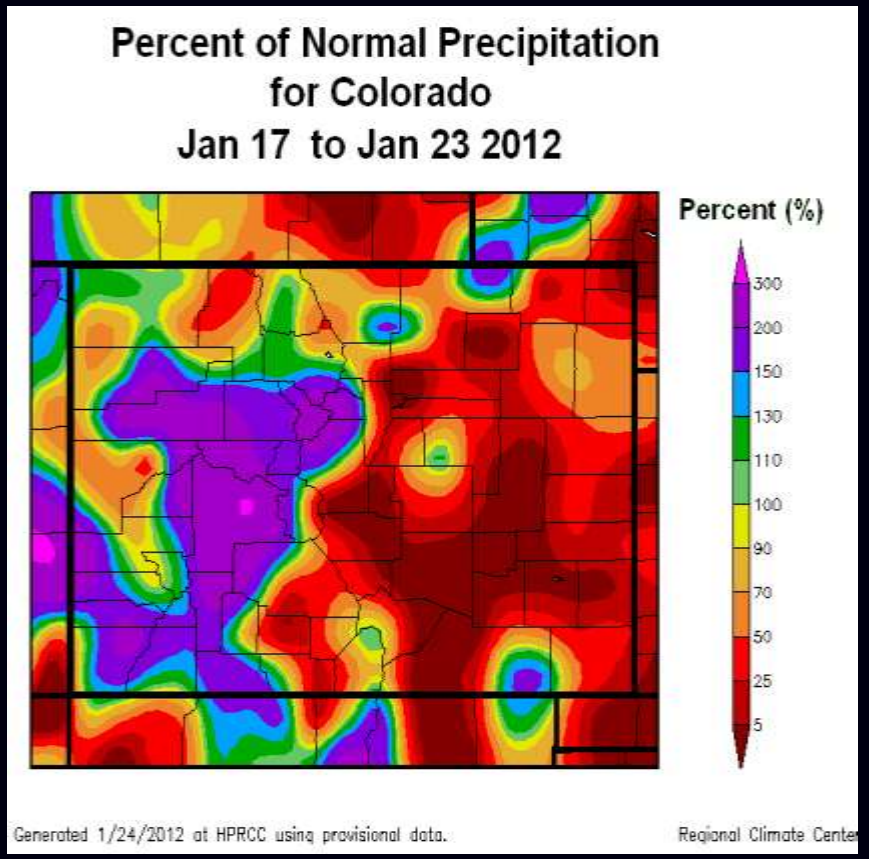
Moderate to very dry conditions were indicated for the rest of Colorado, except for pockets of near normal moisture conditions in the Elk and West Elk Mountain Ranges in west central Colorado and southern portions of the Front Range in east central Colorado.



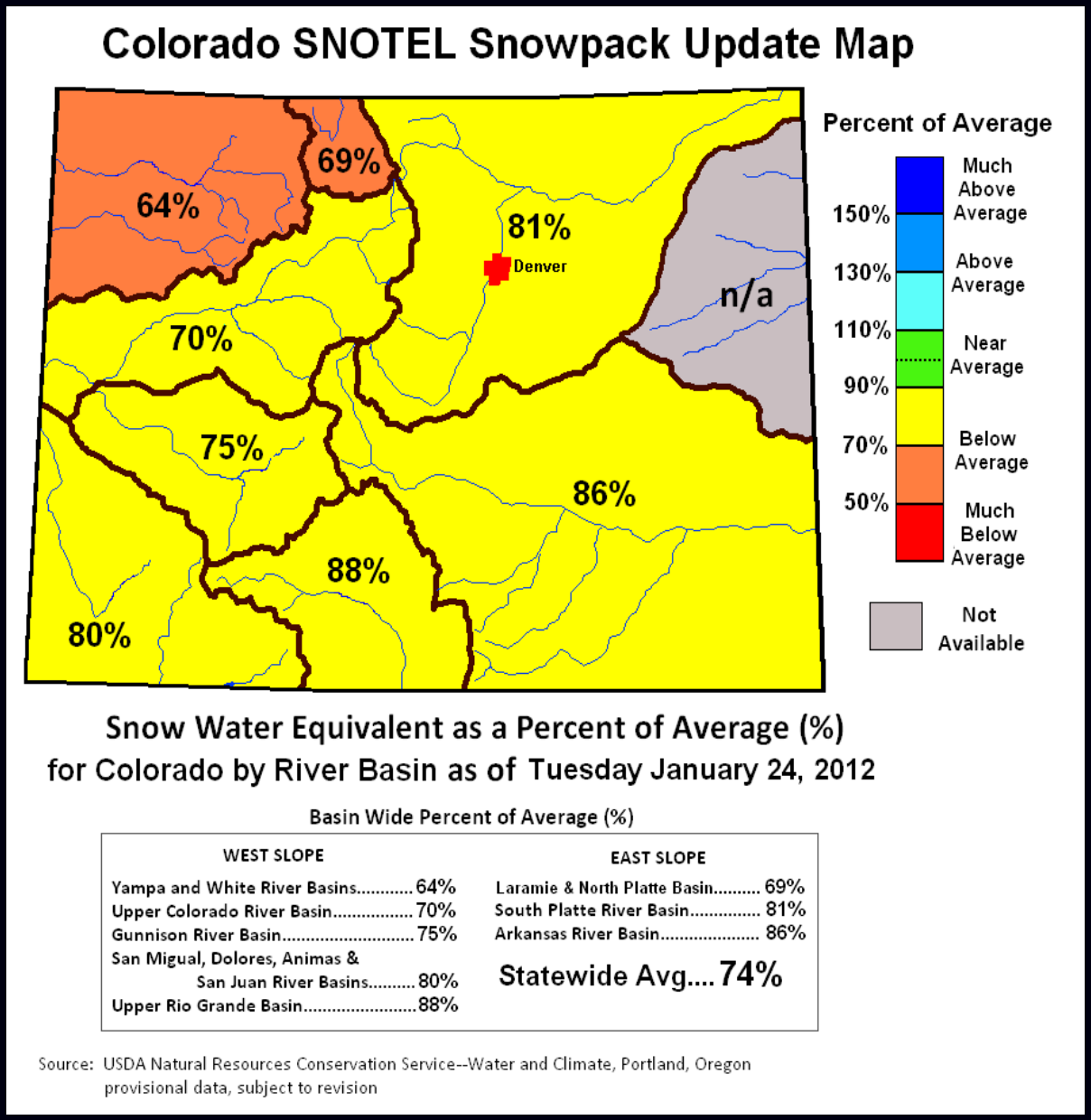
Temperature departures across Colorado continued to trend upward during the 30-day period ending January 23, 2012. The greatest positive anomalies were indicated on the western slopes from the northern San Juan Mountains northern to the Wyoming border, and across most of northeast and east central Colorado.

Pockets of colder than normal temperatures were observed in south central and southeast Colorado.





A turning point in the large scale weather pattern over the western U.S. produced a dramatic reversal in the distribution of precipitation across Colorado during the middle of January. Areas west of the Continental Divide that were dry to extremely dry, had now become wet to extremely wet with above to much normal precipitation/snowfall. Areas east of the Divide saw a significant decrease in precipitation with a persist and sometimes strong westerly downslope flow.



Snow Water Equivalent as a Percent of Average (%)
for Colorado by River Basin as of Tuesday January 24, 2012

Basin Wide Percent of Average (%)

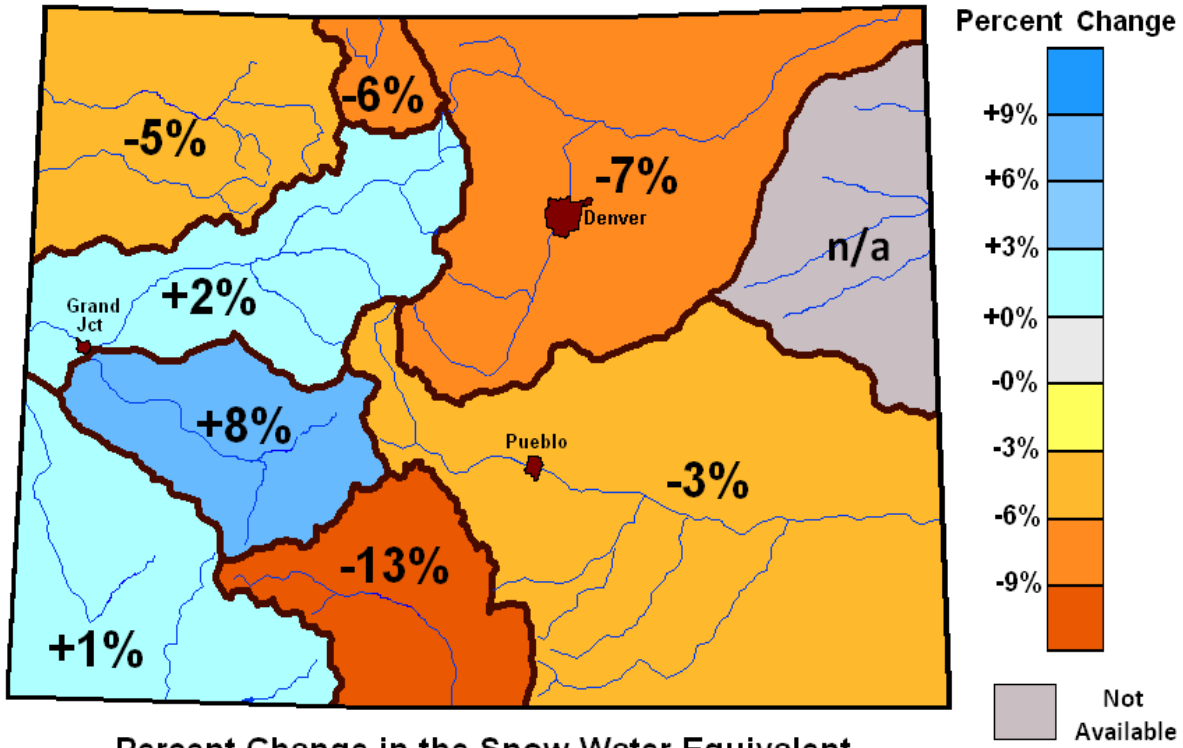
WEST SLOPE		EAST SLOPE	
Yampa and White River Basins	64%	Laramie & North Platte Basin	69%
Upper Colorado River Basin	70%	South Platte River Basin	81%
Gunnison River Basin	75%	Arkansas River Basin	86%
San Migual, Dolores, Animas & San Juan River Basins	80%	Statewide Avg....	74%
Upper Rio Grande Basin	88%		

Source: USDA Natural Resources Conservation Service--Water and Climate, Portland, Oregon
provisional data, subject to revision

Snowpack in Colorado as of January 24, 2012 was below average overall, with the least snow water equivalent recorded across the northwest corner of the state.

Statewide, the snow water equivalent averaged 74 percent of normal, a far cry below what was observed this time last year.

Colorado SNOTEL Snowpack Update Map



Percent Change in the Snow Water Equivalent By River Basin from Dec 22 2011 to Jan 24 2012

WEST SLOPE		EAST SLOPE	
Yampa and White River Basins	-5%	Laramie & North Platte Basin	-6%
Upper Colorado River Basin	+2%	South Platte River Basin	-7%
Gunnison River Basin	+8%	Arkansas River Basin	-3%
San Migual, Dolores, Animas & San Juan River Basins	+1%	Statewide Avg....	-3%
Upper Rio Grande Basin	-13%		

Based on SNOTEL data provided by USDA Natural Resources Consevation Service - Water and Climate, Portland, Oregon
provisional data, subject to revision

From December 22, 2011 to January 24, 2012, the change in snow water equivalent in Colorado's eight major river basins ranged from +8 percent in the Gunnison River Basin in west central Colorado to -13 percent for the Upper Rio Grand Basin in south central Colorado.

The Yampa and White River and the Laramie and North Platte Basins in northwest Colorado continued to fall behind on their snow pack, while the eastern plains under went a reversal in its snowpack water equivalency during the period.

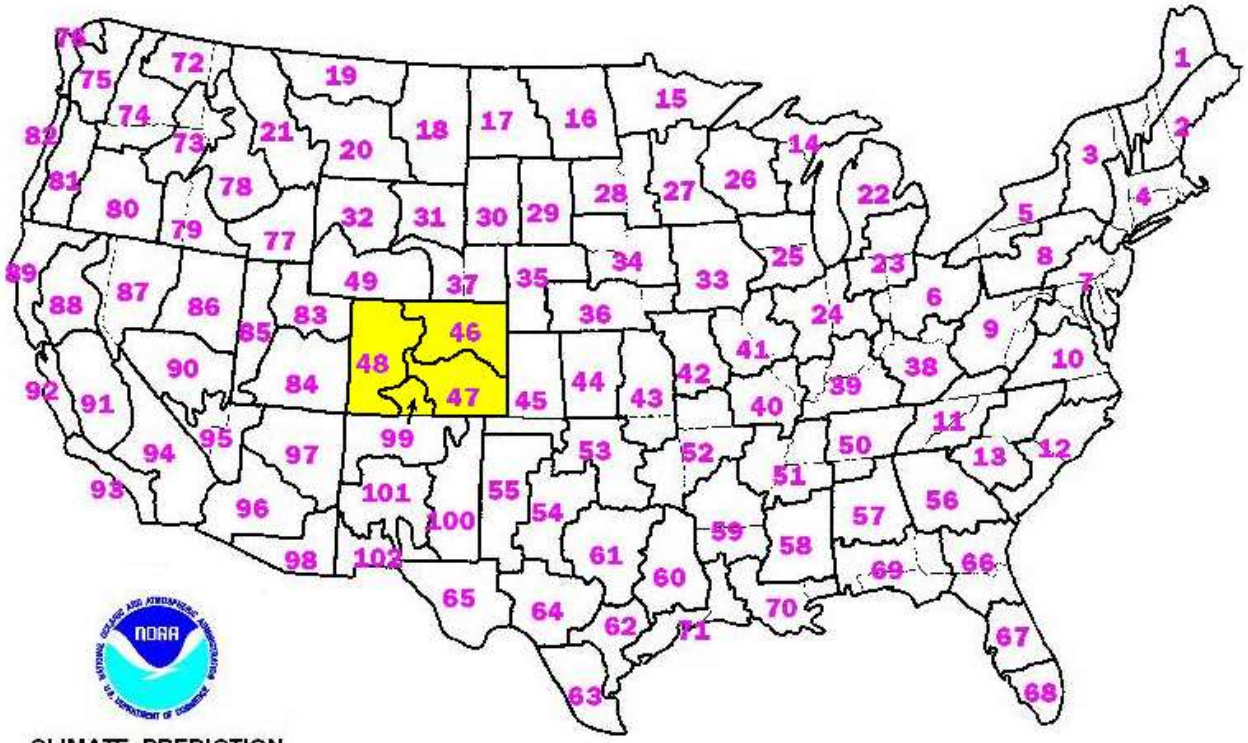
February- April 2012 Temperature and Precipitation Outlook for Colorado Issued by NOAA's Climate Prediction Center

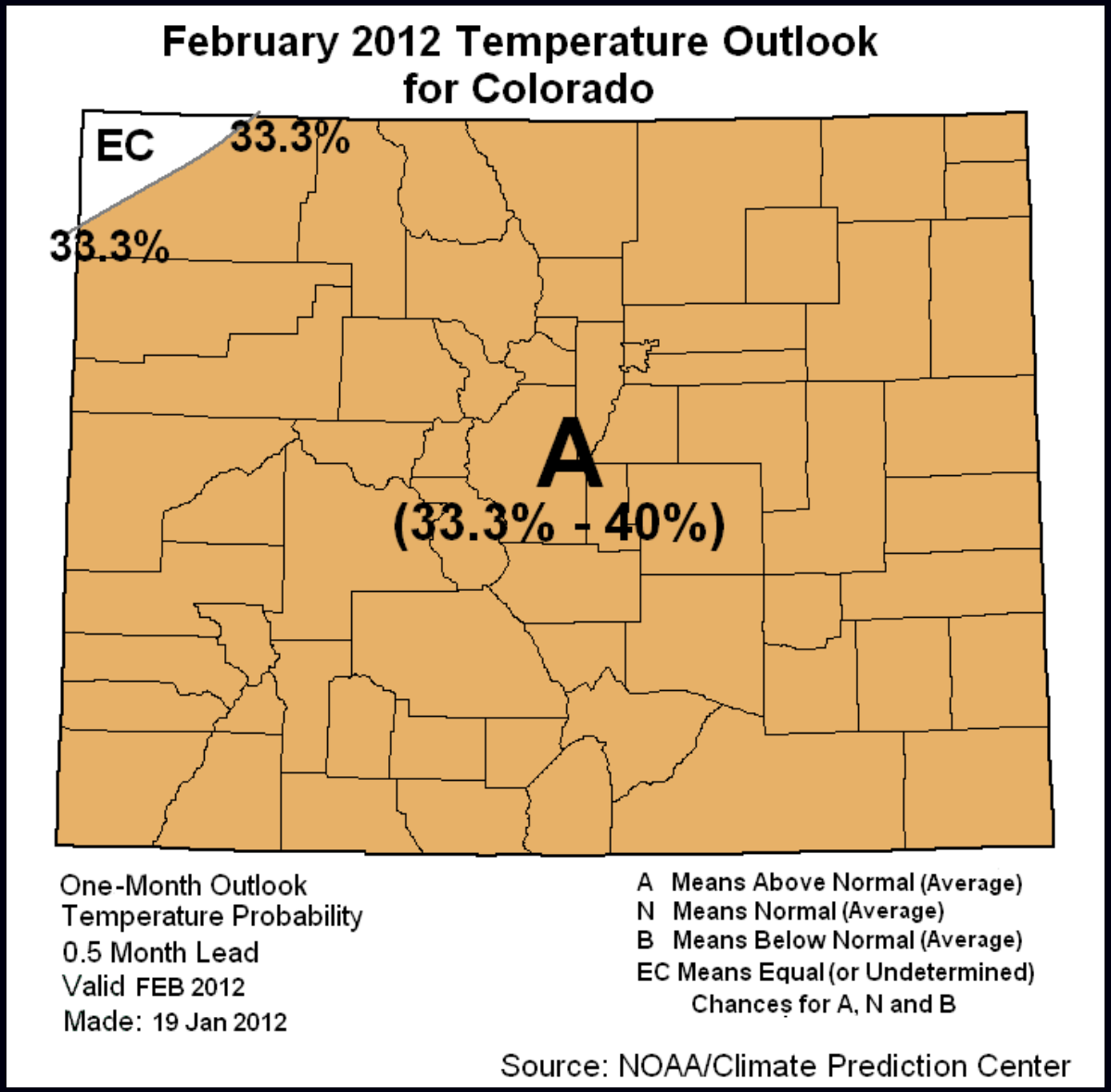
Climate Prediction Center Seasonal Outlooks

The National Weather Service Seasonal Climate Outlooks predict the probability of conditions being among the warmest/coldest or wettest/driest terciles of years compared to the period of record 1981-2010.

The outlooks indicate probability of being in three specific categories in reference to the 30-year climatology from 1981-2010. They are above, below and average.

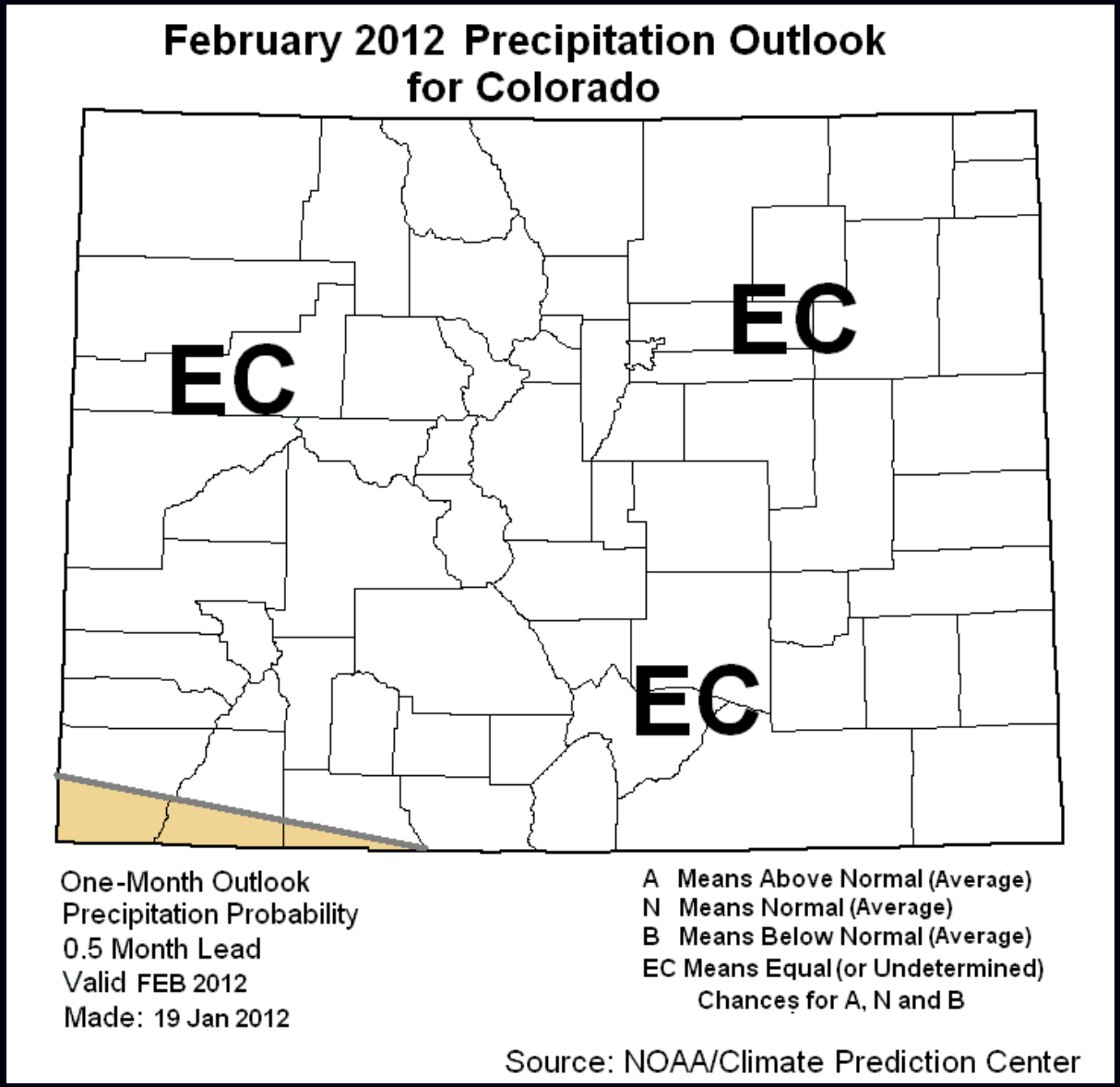
Remember, Climate Predicition Center (CPC) outlooks are made at the scale of the climate megadividions (see the map below).





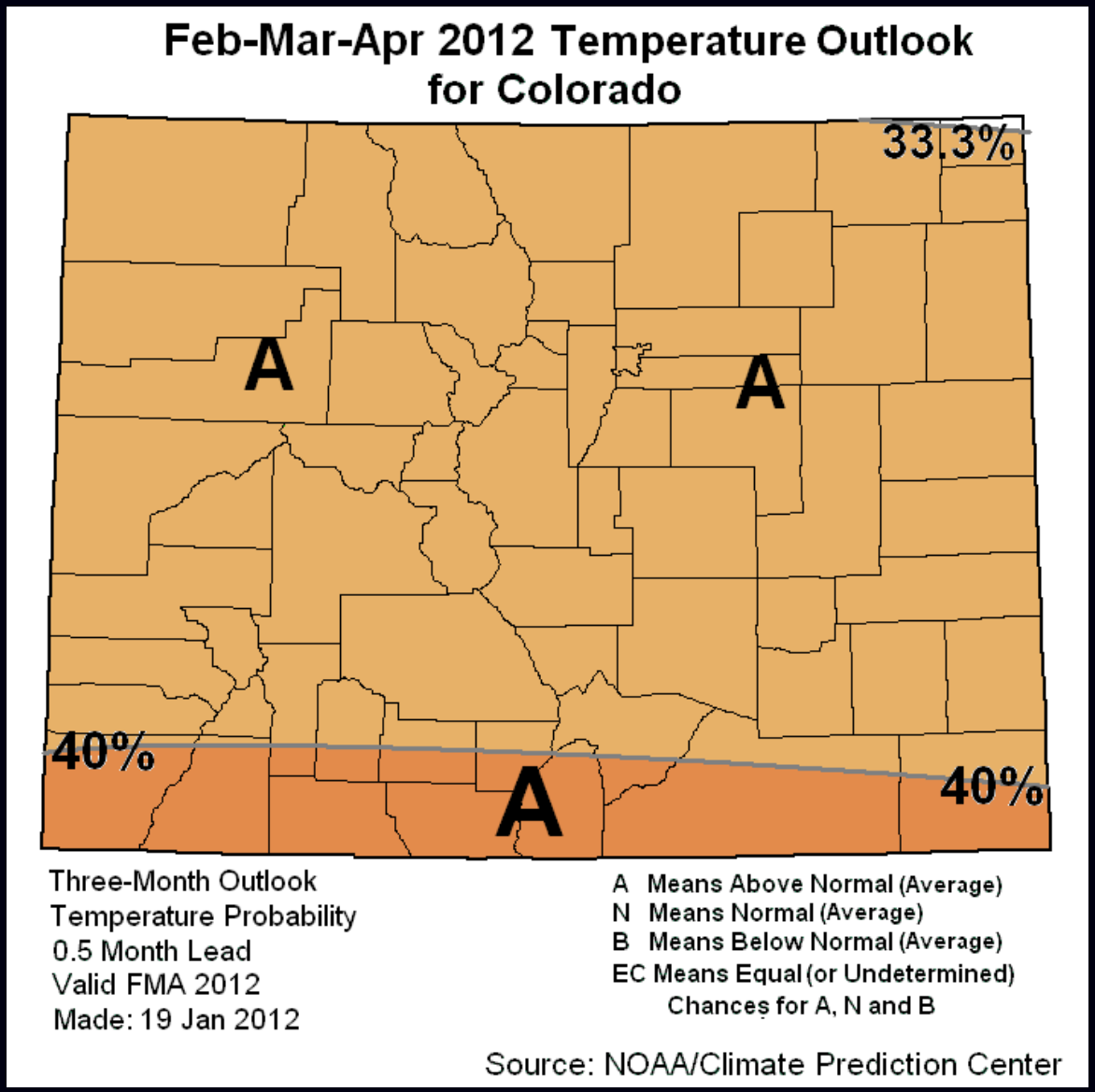
February 2012 Temperature Outlook for Colorado

The latest one-month temperature outlook from NOAA's Climate Prediction Center (CPC) calls for a 33.3 to 40 percent chance of above average temperature for nearly all of Colorado for the month of February.



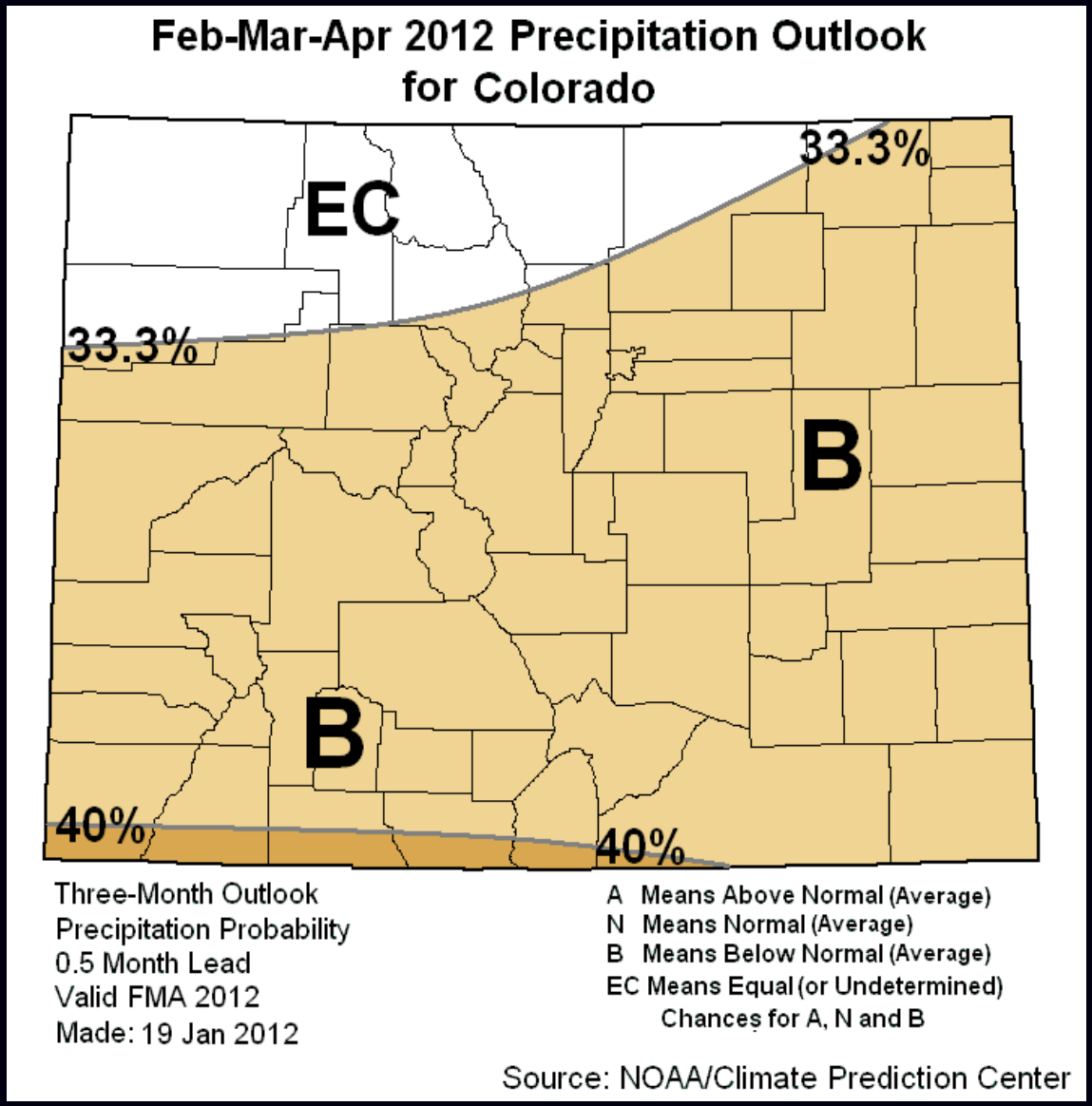
February 2012 Precipitation Outlook for Colorado

The February outlook from CPC calls for an equal (or undeterminable) chance of above, below and near average precipitation for essentially all of Colorado, as indicated by the EC symbol.



February-April 2012 Temperature Outlook for Colorado

The temperature outlook for February-April from CPC calls for a 33.3 to 40 percent chance of above average temperature for all except the southern one-sixth of Colorado, where there is a better chance to see warmer than average temperatures.



February-April 2012 Precipitation Outlook for Colorado

Finally, the latest precipitation outlook from CPC calls for a 33.3 to 40 percent chance of below average precipitation for the lower 80 percent of the state. For the remainder of the state, the outlook is for an equal (or undeterminable) chance of above, below and near average precipitation during this three month period—as indicated by the EC symbol.

With the ongoing La Niña, odds favor above average precipitation across the northwest corner of Colorado, at least during the months of February and March.

Summing It Up…

- A consensus of the dynamical and statistical climate models indicates the presence of a weak to moderate La Niña through the February-April 2012 climate season, then a transition to ENSO-neutral conditions during the remainder of the 2012 spring season.
- During the past 90 days, precipitation across Colorado was generally below to much below average across the western part of the state and near to above average for the remainder of the state. In the last 30 days, southern and eastern portions of the state began to experience an overall decrease in precipitation as storms were no longer moving in from the desert southwest, but rather from the west and northwest. In addition, temperatures were generally near to above average across Colorado during the last 30 days, and near to above average for southern and eastern sections of the state.
- By the middle of January, a significant shift in the large scale circulation pattern over the western U.S. favored a return to above to much above average precipitation for the Pacific Northwest and the western slope of Colorado. Areas east of the Continental Divide in Colorado saw a marked decrease in precipitation due in large part to the drying and warming efforts of a persistent and often strong downslope flow off the Front Range mountains.
- The latest climate outlook from the Climate Prediction Center (CPC) calls for an equal (or undeterminable) chance for above, near and below average precipitation across Colorado during February, and at least a 33.3% chance for below average precipitation for nearly all of Colorado during the February-April climate season. CPC is also calling for above average temperatures (at least a 33.3% chance) across nearly all of Colorado during February and the three-month climate season February-April 2012.